The
Tropical Agriculturist
March, 1934

EDITORIAL

CLOVES AND OTHER THINGS

THE Government of Zanzibar last year sent a mission to the spice producing countries of the East, including Ceylon, to investigate the position and possibilities of the clove industry. Zanzibar is in that most invidious agricultural position of being practically a one crop producing country. The danger of such a position is one to which we have before drawn attention and the wisdom of Ceylon peasant agriculture avoiding such a situation wants to be fully realised.

Ceylon's position in tropical agriculture was at one time almost that of a spice island and one is inclined to wonder whether she may not have abandoned that position somewhat too readily. She is endowed with some spices such as cinnamon, indigenous to her, and the likes of which can be produced nowhere else. Indeed nature has more than normally blessed Ceylon in the matter of her crops, the writers of the report express apprehension at the high grade quality of the cloves that Ceylon produces, the yield of the trees, and the profitableness of the industry. In the clove industry Ceylon is almost self satisfying. The industry in Ceylon like that of most of our agricultural products shows that we are too complacent and too easily accept this matter of "self satisfaction" and that there is something more required as a stimulant to the trade of this Island beside the bounteous response of nature, indeed nature may possibly be too kind to us and not sufficiently harsh to force us into lines of commercial acumen other than mere production. Is it not possible for us to think more imperially to our own

advantage? Could not our cinnamon industry be revived on somewhat the same lines as Mysore has developed her trade in sandalwood oil ? Is it not possible by a control of prices for our paddy growers to produce more than the insufficiency for their own needs when the present unremunerative rates will never encourage them to produce for the town? And all the time as if in mockery the town cries "Eat your own rice" and purchases the imported article at the cheapest possible rate.

India imports annually some 71,000 cwt. of Zanzibar cloves and some 1,000 cwt. from elsewhere, including Ceylon, and among which is a potentially increasing quantity from Madagascar. Indian production of cloves is on an insignificant scale. Again we see Ceylon's position to be affected by a factor adverse to nature's kindness in production. The Clove Commission report South India provides a convenient market for our produce but of the present smallness of our trade they were "unable to establish whether this export trade had developed because the high-grade quality of the Ceylon product provides an excellent basis for adulteration or because the proximity of certain South Indian ports especially Tuticorin makes it cheaper for them to purchase from Colombo than from Bombay"—an astounding statement showing that adulteration and mere rolling by gravitation as it were are the factors in our state of complacency that are controlling our trade.

Our tea and rubber planters have at one time or another, at all events for a time saved the situation by limiting the production. Our coconut plantations are powerless to pursue this palliative for other countries present abundant other oil seeds ready to take their place. Is it not just possible that in these matters we are thinking too parochially and not sufficiently imperially ? Certain it is that our friends in the tea industry have acted very wisely and seen to it that whilst production stands still for a time they have taxed themselves to carry on an intensive and wide propaganda to stimulate consumption. We import from abroad especially India enormous quantities of food materials. Are not coconuts, cinnamon, cloves, paddy and innumerable other things capable of exploitation if we only entered into an imperial and not parochial system of barter always of course remembering that charity begins at home ?

An equitable import tax on paddy alone, which would hurt no one and greatly benefit our peasantry, could afford this country an enormous opportunity to barter.

CEYLON'S IMPORT TRADE IN CITRUS FRUIT

SUMMARY FOR THE YEAR 1933

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AN article summarising the trade during the past five years appeared in "*The Tropical Agriculturist*", January, 1933. In the present paper is given an analysis of that of the past year.

The total quantity of Citrus fruit of all kinds imported into Ceylon in 1933 amounted to 6,694 cases which was 441 cases in excess of the average for the past five years and 329 cases over the previous year's total.

The distribution of consignments throughout the year was as follows:

	Number of Cases	
	1933	Mean of 5 years
January ...	1,107	896
February ...	643	652
March ...	596	620
April ...	369	340
May ...	530	222
June ...	176	471
July ...	209	650
August ...	460	364
September ...	409	258
October ...	490	282
November ...	621	427
December ...	1,084	1,068
Total ...	6,694	6,250

The deficits in June 295 cases and in July 441 cases were due to a drop in the consignments received from both California and Australia. The total for June is the smallest on record for the past six years. The figures for January, May, September and October 1933 are the highest recorded for the same period. The excess in January was due to larger consignments from Palestine and smaller late arrivals from Australia and Japan;

in May it was due to a heavy late consignment from Palestine; in September to consignments from Australia; in October to an early consignment from South Africa and large consignments from California and Australia, and in November to the commencement of the trade in limes from South India.

The position of the exporting countries in 1933 stood as follows:

	1933		Comparison with other years		
	Number of Cases	Percentage of total imports	1928	1932	1933
Palestine	3,136	46·8	100	416	365
Australia	1,200	18	100	229	221
California	1,026	15·2	100	24	35
South Africa	434	6·4	100	655	1,000
Mediterranean ports	433	6·4	100	66	95
India	405	6·2	100	344	645
Other	60	·8	—	—	—

Palestine.—The imports as recorded for the year dropped by 51 cases from the total for the previous year, but in fact 334 cases of Jaffa fruit which arrived before the close of the year were not released from the warehouses till the 2nd and 3rd of January. The season appears to have been a good one as the imports to Ceylon over a period of 7 months from November, 1932 to May, 1933 totalled 3,397 cases. Hitherto the season of imports ended in April, but in 1932 and 1933 this was extended and in May of each year the imports totalled 175 cases and 429 cases respectively.

California.—There was an improvement in the imports in 1933 against those of the previous year, the figures being 1,026 cases this year against 714 cases in 1932. The percentage of the total annual imports accordingly rose from 11·2 per cent. to 15·2 per cent. As pointed out previously, consignments from California had been received throughout the year, and hitherto the total was divided about equally between the two half-yearly periods. In 1933, however, the figure for the second half-year alone was 844 cases.

Australia.—The imports this year were short of the previous year's total by 46 cases but the average for six years was better than that for the previous five years. The largest quantities received in a single month were 268 cases in September and 250 cases in December.

South Africa.—The quantity received this year was 434 cases as against 282 cases in 1932, but this occurred in three months and comprised four consignments numbering 223 cases in August and two consignments of 100 cases each in October and November.

Mediterranean Ports.—The bulk of the consignments were received in January, 161 cases from Naples, and in December 240 cases from Cyprus.

India.—The imports comprised limes of which 179 bags of 1,500 fruit each were received in November and 155 bags in December.

Other.—In January a consignment of 60 cases of oranges was received from Japan.

Varieties of Produce.—As explained in the previous article there is difficulty in arriving at the exact number of cases of a particular variety owing to the adoption of a single term which covered a consignment of more than one variety. According to the records the following quantities were received:

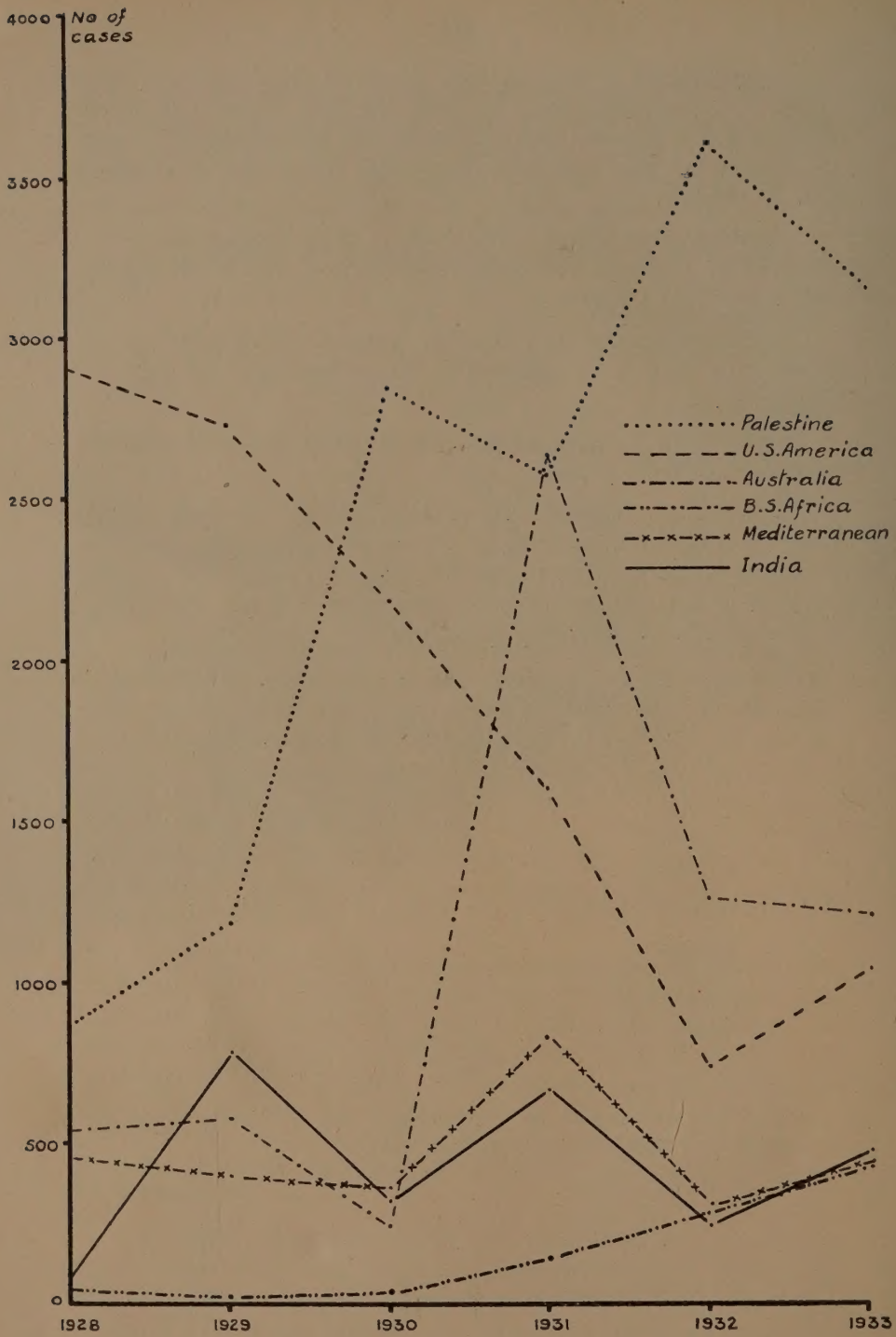
Oranges	3,542 cases
Oranges and Grapefruit ...	1,892 ,,
Oranges, Grapefruit & Lemons	328 ,,
Grapefruit and Lemons ...	37 ,,
Grapefruit	485 ,,
Citrus	57 ,,
Lemons	18 ,,
Limes	334 ,,

An approximate estimate of the varieties separately is:

Oranges	5,044 cases
Grapefruit	1,263 ,,
Lemons	53 ,,
Limes	334 ,,
Total ...	6,694 ,,

The several countries from which the different varieties were received is approximately as follows:

Oranges—Palestine	2,327 cases
Australia	1,198 ,,
California	611 ,,
South Africa	389 ,,
Mediterranean Ports ...	388 ,,
India	71 ,,
Japan	60 ,,



ANNUAL IMPORTS OF CITRUS FRUIT INTO CEYLON
FROM VARIOUS COUNTRIES

Grapefruit—Palestine	... ...	769 cases
California	... ...	415 ,,
South Africa	... ...	45 ,,
Mediterranean Ports	...	32 ,,
Australia	... ...	2 ,,
Lemons—Palestine	... ...	40 ,,
Cyprus	... ...	13 ,,
Limes—India ...	... ...	334 ,,

The duty on Citrus fruit which hitherto had been 10 per cent. and 15 per cent. *ad valorem* was raised as from February 1st to 15 per cent. and 25 per cent. respectively, the higher rate being charged on foreign consignments or on those not accompanied by a declaration of the country of origin.

Following is a statement of the value of fresh fruit and the estimated value of citrus imported in 1932 and 1933:

	1932	1933
	Rs.	Rs.
Total value of all fresh fruit	546,354	522,786
Value of apples and grapes	not shown separately	447,233
Other fruit		75,533
Estimated value of Citrus fruit	63,000	60,000

The accompanying diagram shows the fluctuation of the import trade in Citrus fruit from different countries for the past six years.

NOTES ON ORCHIDS CULTIVATED IN CEYLON

VANDA SPATHULATA SPRENG.

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THIS orchard is an epiphyte and belongs to the magnificent genus Vanda, which counts more than twenty species, most of which attain a considerable size and are among the largest of tropical Asiatic Orchids.

Vanda spathulata Spreng. is indigenous to Ceylon and the South-Western region of India. In its wild state it grows on scrubby bushes and among rocks almost from sea level to an altitude of about 2,000 feet.

Its semi-straggling climbing habit makes the stem long, ten to fifteen feet being not unusual. Only the distal parts of the stem bear leaves.

The leaves are not of uniform size or colour even in plants growing side by side. It often happens that one has green leaves while those on another are speckled with pink or entirely reddish. A similar variation occurs in plants of different elevations. In the dry districts they are clothed with thicker and shorter leaves more closely set, than in a humid atmosphere.

The stem, which is more or less mottled with pink, cylindrical, and slightly thinner than a lead pencil, has the peculiar habit of throwing out roots upwards. These latter are fairly stout, fleshy and long.

The flower stalk, which is about twelve to eighteen inches high, rises from a node close on the terminal shoot, carrying a raceme of mildly scented bright yellow flowers.

The flower is about one and a half inches across. The sepals and petals are obovate-oblong, the tips being rounded and the lip longer than the sepals.

Vanda spathulata Spreng.

Culture.—This is a sun-loving plant that does not respond readily to pot cultivation. The bare and rather "leggy" stems should be cut off at a point immediately below a good root so that when potted the leaves at the bottom of the stem may rest on the top of the compost. About half a dozen cuttings, each a foot high, may be planted in a ten-inch pot with about the same number of stout durable stakes for them to root on.

The compost may be made up of equal parts of bits of old wood, bark, and coconut husk with a few pieces of charcoal being added when potting to maintain aeration and sweetness of the mixture. A good soaking of water may be given on the day of potting but subsequent waterings should be done only on alternate days or on every third day.

The newly potted plants must be placed in a cool atmosphere for a month or more. When new roots appear, the plants may be transferred to a more open place, preferably under the shade of tall trees.

Cuttings placed in hedges or in closely set bushes have been found to do well and to flower freely.

CONTRIBUTIONS FROM THE RUBBER RESEARCH SCHEME (CEYLON)

NOTES ON CROSS-POLLINATION OF RUBBER (HEVEA BRASILIENSIS) IN CEYLON

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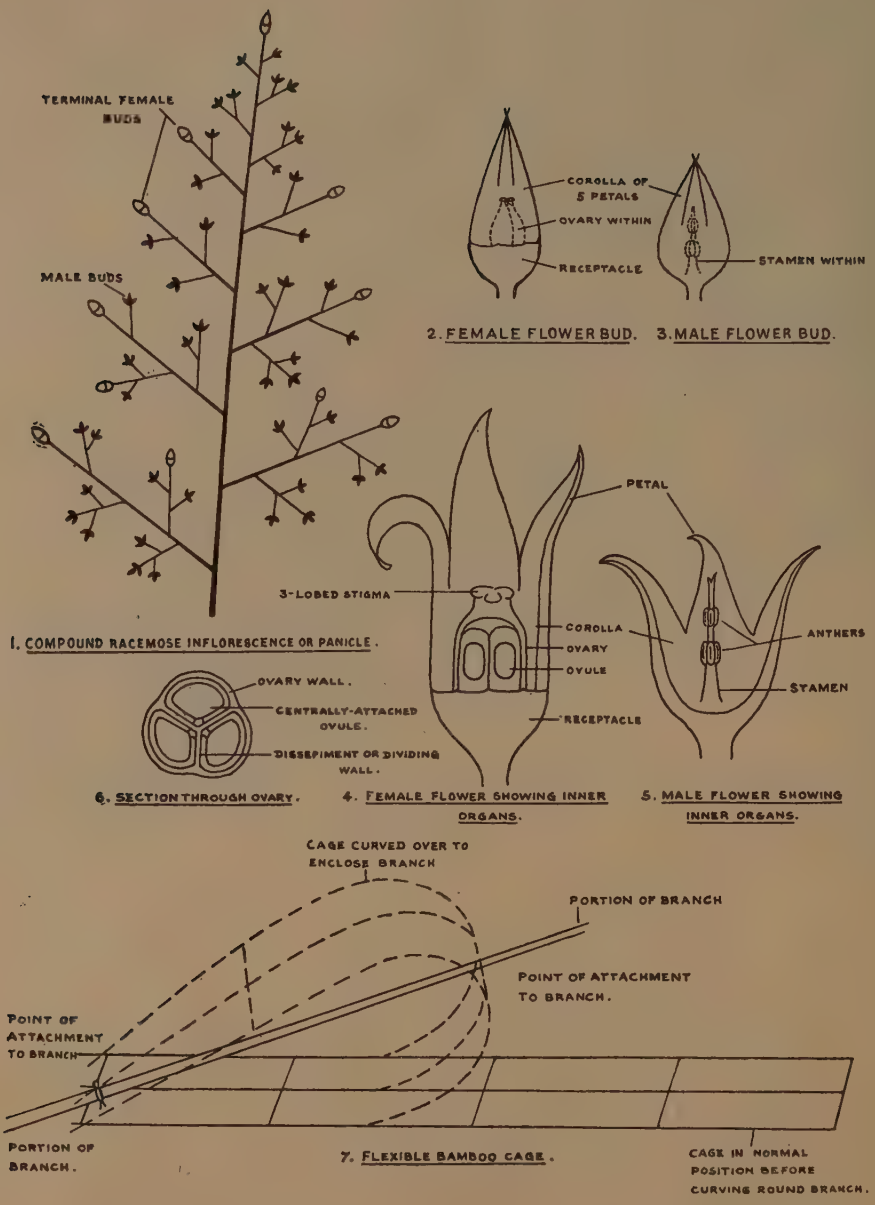
INTRODUCTION

AS there appears to have been little or no previous work done in Ceylon on the above subject it is hoped that the ensuing remarks based on work carried out by the writer at the Rubber Research Scheme Experiment Station, Nivitigalakele, during the past two years may be of interest. It will be known to those connected with the Rubber Plantation Industry that the yield of latex from individual trees varies very substantially. Extensive research has been carried out in Java, Sumatra and Malaya with a view to improving the yield of future plantations both by the asexual or vegetative method of budgrafting with material from selected high yielding trees and by the sexual method of cross-pollinating high yielding trees for the purpose of evolving improved seedling progeny. Work on the former lines has been undertaken in Ceylon at Nivitigalakele where budgrafts from a large number of local high yielding trees have been established but hitherto improvement by artificial cross-pollination of selected trees has not been attempted. The present notes refer mainly to cross-pollination of the flowers of budgrafts at Nivitigalakele which have reached an age at which flowering occurs.

MORPHOLOGY OF FLOWER

A preliminary need in embarking on work of this kind is to acquire a clear knowledge of the anatomy of the flower. The *Hevea brasiliensis*, being monœcious, has both its staminate (male) flowers and pistillate (female) flowers on the same tree (in fact on the same inflorescence—*vide* diagram I), and a close look soon reveals the external difference in form of the one from



Structure of the Inflorescence and Flowers of *Hevea Brasiliensis*. At the bottom is shown the method of making a bamboo cage around the inflorescence.

the other. The female flowers are confined to the terminals of the main and stronger side axes of the inflorescence, which is a compound raceme or panicle, and are larger in size, fewer in number and of different formation to the male flowers. The former (diagram 2) in addition to the corolla of 5 yellow petals has a distinct light-green cup-shaped bottom half-receptacle—whereas the latter (diagram 3) is yellow throughout and has no green receptacle. Under the dissecting microscope the variation in structure is further marked. The "female" (diagram 4) consists of a syncarpous trilocular gynaecium (*i.e.* a 3-celled ovary) standing on the aforesaid light green receptacle and surrounded by the corolla of 5 yellow petals. The summit of the ovary tapers into a blunt three-lobed stigma. The male flower (diagram 5) which has no receptacle reveals, within its yellow corolla, a tiny white perpendicular monadelphous stamen (*i.e.* filaments of stamens united into one) carrying two whorls of 5 yellowish anthers each. Each anther contains 2 pollen sacs, which on dehiscing (generally shortly after the flower opens) sets free the sticky, dust-like, circular pollen grains inside it.

TECHNIQUE AND EQUIPMENT

The method of cross-fertilisation adopted was to take a male flower from the required source, divest it of its petals with as little movement as possible and, getting hold of the bottom of the stamen (see diagram 5) by means of a pair of pointed forceps, to rub that portion of it bearing the now-ruptured pollen sacs gently over the receptive stigma (see diagram 4) of the particular female flower required to be fertilised. The operation is somewhat delicate and care has to be taken not to injure the surface of the stigma by careless or excessive rubbing. Provided the operation has been carried out at the correct stage of development of the flowers, and allowing for other natural causes of failure, the pollen grains so transferred to the sticky surface of the stigma germinate and fertilise the centrally-attached ovules (later seeds) that are inside the ovary. Directly the ovules are fertilised the ovary (seed pod) begins to enlarge and for the first time the success of one's labours may be ascertained. The mature rubber pod belongs to the category of syncarpous dry dehiscent fruit known botanically as a "capsule".

Apart from the technique described above, in experimental work numerous precautionary and safety measures have to be adopted. All inflorescences whose female flowers are to be pollinated are enclosed in muslin or fine transparent cotton-cloth

bags before the flowers open. This is best done at a stage not too early to stifle the flowers and not too late to allow natural fertilisation from unknown sources taking place. In view of the fact that in Ceylon the first male flowers on an inflorescence open 7-10 days before the first "females", a safe stage for bagging is when the first "males" are swelling to open. Careful watch is kept thereafter until the "females" open, upon which they are fertilised with pollen from the particular source selected. To prevent the muslin bag, especially when wet, from sagging against the flowers a bamboo cage (diagram 7) made of flexible strips of split "bata" (*Ochlandra* sp.) is sometimes used. The experience gained at Nivitigalakele however is that except in special instances its use is somewhat superfluous, not to say troublesome, in that the leaf fronds around an inflorescence usually quite successfully perform the same function.

The actual transference of pollen is done with the aid of a pair of pointed forceps about 5 in. long, which also serves to remove the petals of the male flower from the single column-like stamen bearing the pollen. A tall step-ladder and, at times, scaffolding round particular trees, are necessary. Immediate labelling of each inflorescence pollinated is strictly observed so that no mistakes may arise subsequently regarding the crosses made. The label, preferably a non-corrosive metal one, should primarily bear the name (number) of the male parent with which the particular inflorescence was fertilised and, if more than one inflorescence has been done on the same tree, the number of the inflorescence. Accurate records of dates of bagging, pollinating and unbagging, number of flowers pollinated and number of successes obtained are kept for each inflorescence. This is not as tedious as it sounds if entered in tabular form in an exercise book. In experimental work, flowers on a single inflorescence are never fertilised with more than one variety of pollen and an inflorescence is never unbagged until all its female flowers are safely past the stage when they can be further fertilised. This can easily be determined when the stigmas turn dry and change to a dark or brown colour. If speedy unbagging should be necessitated for any special reason, all unopened "females" should first be plucked before removing the bag.

OBSERVATIONS

Results of rubber pollination in other countries show that an average success of over 15 per cent. has seldom been obtained and that a figure below 10 per cent. is far more general. Work done at Nivitigalakele mainly among young budded clones gave,

in 1932, 7 successes out of 103 (7 per cent.) and in 1933 52 out of 822 (6·3 per cent.). It is however interesting to note that, among the pollinations carried out in 1933, whereas a successful percentage of 15 per cent. was obtained from crosses where both male and female parents were mature estate trees, and 9 per cent. where the female was a mature estate tree and the male a young budded tree, only 3 per cent. were successful where both parents were comparatively immature buddings flowering only for the first or second time. Similarly in 1932 mature estate tree crosses gave a success of 29 per cent. as against 2 per cent. from young buddings. Although these results may not be adequate to justify a definite conclusion in view of the fact that subsidiary factors have come into play, they tend to show that flowers of more mature trees incline to give a higher percentage of success than those of younger trees which have only flowered for a season or two; while the total average successes for the two years 1932 and 1933 support the view with limitations, that average successful percentages of over 15 per cent. are more the exception than the rule in work of this kind. The reason for the latter phenomenon has to be sought partly in nature where the rubber tree like most other prolific flowerers has to be controlled against over-production, and partly no doubt from defects in the technique adopted.

The outbreak of *Oidium Heveae* which often manifests itself on the inflorescences during the pollinating season is found, in Ceylon, to be a considerable handicap. Flowers so infected either drop wholesale or do not open, thus affecting both the scope for, and results of, pollination. The interference from this source has been sufficiently great to make it necessary to resolve to undertake sulphur-dusting of inflorescences prior to pollination in future years.

Although it seems reasonable to expect that bagging of inflorescences unduly early may retard or inhibit the proper development of the flowers and their subsequent opening, in actual practice it was found that inflorescences on which bags were put somewhat over-early, that is to say about 12 days before the first males started swelling to open, actually opened some days before ones left unbagged as controls on the same branch and of the same stage of maturity. Certain bags were left round inflorescences to ascertain whether natural self-fertilisation by wind would take place within the bag. In no case did this

occur, tending to show that self-fertilisation of rubber in so far that females of an inflorescence are naturally wind-pollinated by males on the same inflorescence occurs rarely, if at all, although successful self-fertilisation by artificial methods has been recorded by workers in other countries.

Dry weather during the "set" was found to be an important necessity. Wet conditions generally meant that the pollen transferred to the stigmas got washed away before it had time to fertilise the ovules or that the moist conditions persisting inside the bag caused the flowers to rot.

The choice of the parent trees, especially the female, appears to require more attention than one at first is inclined to imagine. Pollinations on certain trees, whether estate seedlings or clonal buddings, give no successes despite the most careful technique and favourable conditions while others set seed much more freely. In this respect it is observed that the robustness and general healthy appearance of the tree in relation to size, colour of leaf, tendency to fruit in previous years, size and appearance of flowers, absence of manifestation of disease, play a not unimportant part and that due observance of these factors may considerably increase the season's successes.

In addition to the aspects of rubber pollination dealt with above several important lines of investigation particularly in relation to the viability and mode of transference of rubber pollen, the actual agents causing natural fertilisation, possibilities of self-fertilisation, etc. remain to be explored. It is hoped to pay due regard to these in the near future when the scope for investigation at Nivitigalakele is larger than at present and when the buddings have reached a more advanced stage of maturity.

THE CLOVE INDUSTRY OF CEYLON

[Extract from the "Report of a Mission appointed to investigate the Clove Trade in India and Burma, Ceylon, British Malaya and the Dutch East Indies," By G. D. Kirsopp and C. A. Bartlett recently published on behalf of the Government of Zanzibar by the Crown Agents for the Colonies. The Commissioners visited Ceylon and made a study of the subject on the spot.]

(I) EXTENT OF TRADE

General.—Cloves represent a very small item in the overseas trade of the Island of Ceylon and constitute a commodity of minor importance in its agricultural production. Inevitably the statistical data for measuring the extent of the trade and of local production are lacking in detail.

Imports.—Cloves imported into Ceylon are not shewn under a separate classification but are included under a general classification "other spices". An examination of the general classification referred to in relation to countries of origin and unit values makes it possible, however, to arrive at a rough estimate of the cloves imported into the Island. The figures of import thus estimated for the period 1922-31 are shewn in Table XVI. In addition to these imports a small quantity of exhausted clove stems reaches Ceylon either direct, or in transhipment from Bombay.

Table XVI.—Statement shewing the approximate quantities of Clove Imports for the years 1922-31

Imports

Year	Country of Shipment				Total
	British India	Zanzibar	France	Madagascar	
	cwt.	cwt.	cwt.	cwt.	cwt.
1922	194	—	12	—	206
1923	18	—	—	—	18
1924	81	—	—	—	81
1925	36	—	—	—	36
1926	85	—	91	31	207
1927	20	—	—	—	20
1928	11	89	20	—	120
1929	235	—	—	—	235
1930	17	—	—	—	17
1931	125	105	—	—	230

It may be added that, in so far as Colombo serves as a transhipment port for Zanzibar cloves, no statistical information is available, particulars of the transhipment trade of the port not being recorded in detail.

Exports.—With regard to the export trade, the returns include a separate classification which distinguishes between cloves of Ceylon production and re-exported cloves. Particulars of the clove exports and re-exports during the period 1922-31 are shewn in Table XVII.

Table XVII.—Statement showing the exports and re-exports of Cloves for the years 1922-31

Re-exports

Year	Destination Maldives	British India	Other Countries	Total
	cwt.	cwt.	cwt.	cwt.
1922	27	—	—	27
1923	28	43	—	71
1924	33	160	—	193
1925	46	18	—	64
1926	44	—	—	44
1927	38	—	—	38
1928	42	75	—	117
1929	76	—	—	76
1930	74	—	—	74
1931	71	—	—	71

Exports

Year	Destination Maldives	British India	Other Countries	Total
	cwt.	cwt.	cwt.	cwt.
1922	3	122	—	125
1923	5	30	10	45
1924	—	59	19	78
1925	7	19	23	49
1926	—	19	7	26
1927	7	52	25	84
1928	—	56	11	67
1929	—	515	2	517
1930	—	85	—	85
1931	—	106	4	110

EXCESS OF EXPORTS OVER IMPORTS

Table XVIII.—Summary of Exports and Re-exports of Cloves for the years 1922-31

(a) Total Exports 1922-31	1,186 cwt.	
(b) Total Re-exports 1922-31	775 cwt.	
	1,961 cwt.	
(c) Total Imports 1922-31	1,170 cwt.	
Excess of Exports and Re-exports over Imports	791 cwt.	

Annual average excess being 79·1 cwt.

During the decennial period to which Table XVIII relates, the average annual surplus of local clove production in Ceylon as represented by the excess of exports and re-exports over imports amounted to some 80 cwt. as under:

(i) Average annual exports of Ceylon produce		119 cwt.
(ii) Average annual re-exports of Foreign produce		78 ,,
Total of exports and re-exports	...	197 ,,
(iii) Average annual imports	...	117 ,,
Excess of total exports over imports	...	80 ,,

The foregoing figures indicate that a remarkably even balance has been maintained between the production and consumption of cloves in Ceylon. From the point of view of other producing centres the trade has for the time being little significance; and as an indication of the relative unimportance of this commodity in the general spice trade of Ceylon it may be noted that in the year 1930 the total imports and exports of spice of all classifications amounted to 486,660 cwt. valued at Rs. 102,50,000. In the consideration of this market it is the potentialities of Ceylon as a centre of clove production that invite particular attention.

(II) MARKETING

Foreign Trade.—As the chief commercial centre of Ceylon, the port of Colombo handles the overseas trade as represented by imports and re-exports of foreign cloves and exports of local production. The cross-movement in the trade arises from the fact that Southern India provides a convenient market for the surplus production, exports to this market tending to exceed the actual extent of the surplus in response to any favourable price movement. We were unable to establish whether this export trade had developed because the high-grade quality of the Ceylon product provides an excellent basis for adulteration or because the proximity of certain Southern Indian ports especially Tuticorin, makes it cheaper for them to purchase from Colombo than from Bombay. Not improbably both factors have operated, but prices quoted in the different markets at the time of our investigation suggested that Colombo is in a very favourable position to supply closely adjacent Indian ports.

The clove trade in Colombo is in the hands of Indian spice dealers whose methods of business are similar to those operated in the bazaars of India. These spice dealers buy outright from Bombay or Zanzibar and sell the commodity, in an adulterated form, to retailers in Colombo and other centres removed from the clove producing areas. They also do a small re-export business to Indian importers in the Maldive Islands.

It will be observed from Table XVI that occasional shipments of Madagascar cloves, represented by the total of France and Madagascar, have reached this market. Insignificant as these shipments may have been they are nevertheless indicative of the manner in which the Madagascar product is capable of gaining a foothold in the markets which formerly looked exclusively to Zanzibar and Bombay to meet import requirements. As between the clove produce of Zanzibar and Madagascar the material issue here, as in India, is one of price.

Internal Trade.—The system of marketing the local clove crop is much in line with that prevailing in Zanzibar. The grower has the option of picking his own crop and selling it to the local produce dealer, to whom he may or may not be indebted, or of leasing it under an arrangement which usually secures for himself half the proceeds of the harvest. The local produce dealers, for the most part Moors, are the intermediaries who sell to the retailers in the district towns, or to the wholesale spice dealers in Colombo.

The locally produced article has the advantages in the home market which arise from the Customs duty of 15 per cent. *ad valorem* on imported cloves and from the price premium due to superiority of quality which, at the time of our enquiry, was represented by the difference between 42 cents per lb. for Ceylon and 40 cents per lb. for Zanzibar, standard quality. The local producer has also the advantage of cheap transport both by road and by rail to every part of the Island, including Colombo.

It follows that, despite the intervention of the middleman and the money-lender, the Ceylon producer is able to obtain a much more satisfactory price for his cloves than the producer in Zanzibar.

The import business operated in Colombo secures that local prices, subject to the adjustments due to import duty, freight and other charges, and the quality premium, are kept closely in line with quotations in the Zanzibar market. But the retail price, as in India, is much less susceptible to variation and as the chief method of retailing is by the pinch sold for 5 cents., or even 1 cent., retail profits are an indeterminable quantity.

(III) ADULTERATION

In the districts served by the locally produced article there is almost an entire absence of adulteration, although dampness and stem admixture is occasionally met with. It is only in Colombo and in connection with the marketing of the imported article that deliberate sophistication is practised.

There is at present no legislation in Ceylon designed to control the adulteration of foodstuffs, and until such legislation is enacted the evil will certainly continue unchecked. At the present moment the restricted character of the trade does not give this feature of the Ceylon clove market any special significance, but should the export of Ceylon cloves develop as the result of an expansion of local production the position may alter. In the event of expanded production the fact that the better quality of the Ceylon article makes it an excellent basis for adulteration would be fully exploited both in Colombo and in India.

(IV) UTILISATION

The uses to which cloves are put in Ceylon are similar to those which account for the bulk of consumption in India. It may be said, that with the exception of the European community all the races constituting the population of Ceylon are addicted to the regular use of spices for the flavouring of curries and other foodstuffs. It is true that there is a great variety in the dietary of the domiciled Ceylonese than in that of the peoples of India, and it may be assumed that spices, including cloves, are

a less indispensable item of the household budget than is the case in the sub-continent. The general standard of living in Ceylon is however, higher than in India and even during periods when high prices are ruling cloves are rarely beyond the reach of the bulk of the population.

In the preparation of the betel-nut "pan" the clove plays the same rôle here as in India, and the habit of chewing has a similar prevalence.

The medicinal value of the clove is widely recognised throughout the Island and is in common use as a household remedy and as a stand-by of Ayurvedic medicine, Ayurvedic practitioners being among the largest purchasers of cloves from retail dealers.

Ceylon does not appear to offer any new outlet in the field of utilisation, and it may safely be assumed that any increase in consumption resulting from the exploitation of a new local market would tend to stimulate local production rather than benefit import business.

(V) LOCAL PRODUCTION

While the trade returns record the exports of Ceylon cloves to foreign countries, there are no statistical data regarding the local output or the areas planted under clove trees. The extent of local production cannot therefore be measured and indirect evidence on the subject is somewhat contradictory.

The facts regarding utilisation suggest that the domestic consumption of cloves in Ceylon, with its population of over five millions, must be considerable. Approaching the question from this angle, one authority who undertook enquiries on behalf of the mission estimated that about 1,000 cwt. of cloves are required annually to satisfy the local demand. This estimate reflects a per capita consumption corresponding very closely to that existing in India, and the general character of the trade and of consumption suggests that this figure must be fairly near the mark.

A local consumption of 1,000 cwt. added to a net surplus for export of 80 cwt., places Ceylon production at an average figure of 1,080 cwt. per annum. Such a production would imply that there are about 17,000 bearing clove trees throughout the Island.

The information in the hands of the Agricultural Department, inevitably based upon reports lacking in detail but obtained through Agricultural officers in close contact with the cultivators, did not appear to bear out the existence of so extensive a cultivation. And our enquiries regarding the stocks handled by the wholesale dealers also appear to establish that the arbitrary figure of 1,000 cwt., as representing local consumption is definitely on the high side.

Whether the actual extent of production required to meet local demand reaches 1,000 cwt. per annum or is represented by a somewhat smaller figure, the significant feature of the position is that any expansion of output will leave a larger surplus available for export to India or to other markets now dependent upon Zanzibar as a chief source of supply.

(VI) ASPECTS OF CULTIVATION

In a note prepared for the mission, the Director of Agriculture, Ceylon, gives the following particulars regarding the history and cultivation of the clove tree:

> "Cloves were introduced into Ceylon probably about 1830, a century ago. A small grove of about seven trees was established in the Royal Botanical Gardens about this time and another of twenty trees some years later. The Report of the Director, Royal Botanic Gardens for 1873 stated that the tree was bearing abundantly at Peradeniya. The first trees were then 43 years old. In 1883 it appears from a brief statement made by the Government Agent, Central Province that clove plants were distributed to headmen throughout the Kandy district and these had been established successfully in certain divisions. This would account for the presence of some 85 trees, about 48 years old, in the Harispattu division in which at the present time some three hundred trees in all have been enumerated. Cloves are also found around Gampola and to some extent in Dumbara.
>
> "It would appear that a first consignment of cloves was forwarded to the London market in 1882. About this time it is probable that cloves were introduced into the Ratnapura district where 200 trees interplanted in tea are now to be seen on Allerton Estate, Rakwana.
>
> "Cloves do not appear to have been planted systematically as a crop. Trees have been indiscriminately planted and are not found in compact groves."

In spite of the casual nature of existing cultivation there is, at any rate in the Kandy district, evidence of a growing interest in the clove tree among a number of the Sinhalese small-holders. This interest has been stimulated by the serious fall in the prices of other agricultural products and the comparative immunity hitherto enjoyed by clove prices. With produce prices at levels recently ruling the clove crop is one of the most profitable harvested from the peasant gardens in the district and an extension of planting is generally anticipated.

We were informed that in one area a block of 1,000 trees was in existence and in one of the small holdings which we visited between 100 and 200 young trees had been established. The trees had been obtained as seedlings at a cost, it was stated, of one rupee per plant. Although planted among a variety of other trees such as coconuts, mangosteens, rubber and cocoa, the clove trees appeared to be well-tended and in a healthy condition. This cultivator had shewn the enterprise to clear existing cultures in order to make room for his clove seedlings, and although he was no doubt an exceptionally progressive type of small-holder, we formed the impression that in the matter of energy and practical training in agriculture his class as a whole is very much in advance of the average Zanzibar producer.

If the aptitude of the Sinhalese small-holder makes him potentially a formidable competitor to the Zanzibar clove grower, there would appear to be no impediment to extended cultivation on account of soil and other conditions affecting the growth of the clove tree. Reference has already been made to the excellent quality of the cloves produced. In size the flower-buds are rather smaller than those of Zanzibar, but in formation and colouration the Ceylon product is the better. The trees we inspected seldom showed signs of disease, and although more elongated than the usual Zanzibar type and characterised by an absence of lower branches—possibly removed to facilitate cultivation—their average yield appeared to approximate closely to that obtained in the Protectorate. It is of interest to record that one tree which we saw—obviously of a considerable age but in excellent condition—had, according to its owner, yielded as much as 1,000 lb. of green cloves in a season. The stems are small, closely resembling the stem of a cherry, and at present are never marketed except occasionally when the unstemmed clove is offered for sale.

It may be added that in the Kandy District the clove tree does well at an altitude of some 1,600 ft., and some fifty miles or so from the sea, proximity to which has been held to be essential to successful cultivation. These conditions may account for the slowness with which the trees reach the bearing stage, 12 to 15 years being the usual period required. Recent planting does not therefore entail a serious threat of early competition from an extension of the Ceylon output, and our general impression is that the interest now being shown in the crop will only be sustained by a persistence of the present price relationship of cloves and of the other products cultivated by the Ceylon peasantry.

CITRUS CANKER IN CALIFORNIA*

ALTHOUGH citrus canker has been described as one of the most destructive plant diseases known, the principal effects are not so much an actual killing of the tree as a disfiguration and spoilage of the fruit for market. Canker causes a development of brown, corky, scabby spots and areas on all parts of the tree above ground, especially on the fruit, leaves, and twigs when they are still fairly young and tender. The affected growth becomes disfigured and weakened and the fruit is ruined for market. Under favourable conditions the disease spreads rapidly and becomes very abundant, injuring a large percentage of the fruit.

Citrus canker is a bacterial disease, caused by *Bacterium citri,* which attacks all varieties and species of citrus to a greater or less extent. These bacteria live and multiply abundantly in the affected tissue and are easily carried from one tree to another.

Canker is considered the worst disease of citrus trees which has ever been introduced into this country and its eradication after it had become well established in Florida must be looked upon as an achievement of the greatest importance to the citrus industry.

Hosts.—Citrus canker varies in its seriousness in different species and varieties of citrus. Of the important citrus fruits in Florida the disease is most virulent on the grapefruit and next on the sweet orange. There is some difference in susceptibility between the different varieties. The Washington Navel orange is very susceptible. The lemon in Florida is somewhat less susceptible than the sweet orange, the Satsuma orange is less susceptible than the lemon, and the Mandarin orange is very resistant.

History and Geographic Distribution.—Canker is not widely distributed throughout the citrus-growing countries of the world but is very prevalent in the Orient. It is usually believed to be native to China but has been present in Japan and the Philippine Islands for a long time. Some recent evidence from old herbarium specimens indicates that it may have originated in India (Fawcett and Jenkins, Phytopathology, in press). The disease also spread to many parts of the Orient, the Hawaiian Islands, North Australia, and South Africa.

* Extracted from Bulletin No. 553, July, 1933, University of California College of Agriculture Agricultural Experiment Station, Berkeley, California.

TABLE

SUMMARY OF QUARANTINES AGAINST CITRUS CANKER

Commodity affected	Degree of exclusion	Quarantine	Districts quarantined against
Citrus fruit	Total	Cal. Quar. Ord. No. 1, N. S.	All of the United States, except Arizona
	Total except oranges of the Mandarin class may enter under permit	Fed. Quar. No. 28	India, Siam, Indo-China, Malayan Archipelago, Philippine Islands, Oceania (excepting Australia, Tasmania, and New Zealand), Japan, including Formosa and islands adjacent to Japan, Union of South Africa.
Citrus seed	May be imported under permit and treatment	Cal. Quar. Ord. No. 1, N. S.	All of the United States, except Arizona.
Citrus trees, scions, etc.	Total	Cal. Quar. Ord. No. 1, N. S.	All of the United States, except Arizona.
	Total	Fed. Quar. No. 19	All foreign countries and localities.

In the United States citrus canker was observed in a single case in Florida in 1912, and again in 1913. It was probably first introduced at some time between 1908 and 1911. The disease was not generally recognised as a serious menace until 1914, and its true course was not discovered until 1915. It seems therefore that canker did not attract attention as a serious citrus disease anywhere in the world until it had been introduced into Florida. The disease has been found in Texas, Mississippi, Alabama, Louisiana, and Florida. It has never been observed in California or Arizona nor in Cuba or Puerto Rico. After canker was discovered in Florida it spread rapidly and a vigorous campaign was started by state and federal authorities to eradicate the disease from Florida and the other Gulf states. As a result of this energetic campaign there has been no commercial damage to Florida citrus groves from this disease since 1922 and no infections have been found since 1927. It appears that canker has

been completely eradicated from Florida, Alabama, Mississippi, and Texas and all except one non-commercial area in Louisiana. It also appears to have been eradicated from Northern Australia and South Africa.

Economic Importance.—In Japan the Satsuma and other types of citrus which are commonly grown are not very susceptible to canker and the disease is not considered serious. In fact, it had attracted very little attention there and was generally confused with scab before its outbreak in Florida. On sweet oranges in Japan, however, there is considerable loss from canker.

In Florida both climatic conditions and the types of citrus most commonly grown seem to be particularly favourable to the development of this disease. The grapefruit, which is of especial commercial importance in Florida, is very susceptible, and the sweet orange is also very readily attacked. Citrus canker is therefore of much greater concern to Florida than to any other part of the world where the disease has occurred. In view of the rapid development of canker which took place in Florida between the time of its first appearance and the commencement of the eradication program and the destructive effect which it showed during that period, there can be little question that the Florida citrus industry would have been very badly affected if the disease had been allowed to continue. Unless some method of control could have been found it seems reasonable to believe that a very large percentage of all the oranges and grapefruit would have become affected in a disastrous manner.

During the eradication campaign it is stated that between 1914 and 1931 more than $2,500,000 of state, federal, and private funds were spent in combating citrus canker in Florida alone and the total cost of this disease to the state was much greater than this, since in the eradication campaign 257,745 grove trees and 3,093,110 nursery trees were destroyed incidental to the eradication of this disease, which occurred in 515 properties scattered through 26 counties.

Possibility of Control.—Some control of citrus canker has been obtained in the Orient (and in South Africa before eradication) by spraying the trees. By this means it is possible to prevent the disfiguration of the fruit at least to a certain extent. The possibilities of such control are very limited, however, especially where conditions are favourable to the disease, so that in Florida and also in South Africa campaigns were undertaken to eradicate canker from the affected regions. This work was carried out by a systematic inspection of citrus groves and nurseries and immediate destruction by fire of all affected trees as soon as discovered. By this method, which was repeated as long as any case could be found, eradication was successfully accomplished in Florida and according to Doige (1929), in South Africa.

Adaptability to the California Environment.—The climatic conditions most favourable to citrus canker have been studied quite thoroughly by Peltier (1926) with the following conclusions:

Considering the temperature factor alone citrus canker could develop in all the citrus regions of the world some time during the growing season. The period over which it would be active depends on the number of months having a mean temperature of 68°F or above. The disease would be most severe at points having the greatest number of months with mean temperatures of 80°F or above. Temperature is in no case a limiting factor for the development of canker in any of the citrus regions of the world. Considering the moisture factor, a deficiency of precipitation during the growing season is the limiting factor in the development of citrus canker. Whenever the temperature and precipitation curves are ascending and rounding curves as they are for localities like the Gulf Coast states, China, and even South Africa, conditions essential for the development of canker

are at hand, as these same conditions stimulate the rapid growth of the host plants and thus make them more susceptible. On the other hand, no canker has ever been found in those localities where, while the temperature curves are ascending and rounding ones, the precipitation curves are descending. In California when the highest monthly mean temperatures are reached the amount of precipitation is at its lowest point. If most of the annual rainfall occurred during the summer months rather than during the winter season, canker could develop to some extent as conditions would then be similar to those prevailing in South Africa and at Laredo, Texas, in 1916. The amount, frequency, and seasonal distribution of precipitation is a limiting factor. Apparently the seasonal distribution is the most important factor to consider, for on the seasonal distribution of rainfall depends to a large extent the development or inhibition of this disease in the citrus regions of the world. According to the observations and conclusion of Peltier it does not seem probable that citrus canker would thrive under California conditions, owing to the dry summers. It will be seen from Peltier's conclusions that for the development of this disease it is necessary to have a combination of wet weather and high temperature. In other words citrus canker is most active in regions with a warm, rainy summer, and least likely to develop in places where the summer is dry and rainfall occurs mainly in the cooler part of the year. This would suggest that citrus canker might not flourish in California, or that if it should become established it might be rather easily controlled and eradicated. If it should become established here, however, it might result in anti-California quarantines, even though it occurred in a very mild state.

Methods of Dispersal and Avenues of Entrance.—Canker is spread locally by wind, insects, pruning or other tools, and by any agency which might pass from one citrus tree to another. Over long distances the disease may be carried either on nursery stock or on citrus fruit, since both the tree and the fruit are attacked. In the case of the introduction of citrus canker into the Gulf states, and no doubt elsewhere into new countries, the disease has spread by means of infected nursery stock. In this country it appears to have been introduced first on seedling trees of trifoliate orange shipped from Japan to Texas, Mississippi, Alabama, and Florida, where it spread to other varieties. It was also introduced on Satsuma orange trees shipped from Japan. In Florida, canker also developed in shipments of trifoliate orange trees from Texas. There is no evidence that the disease has ever been spread over long distances on citrus fruit. The most probable method by which citrus canker might be introduced into California would be by the shipment of infected citrus nursery trees from the Orient. If such trees should be brought in and planted in this state the disease would presumably develop on them. After that it might either continue to develop and spread to other adjacent trees, if conditions were favourable, or otherwise it might die out and disappear. Next in importance would be the danger of the introduction of canker on affected citrus fruit, probably either sweet oranges or grapefruit. In this case the only way in which the disease could become established here would be for orange or grapefruit rinds having cankers that contained live germs of the disease to be thrown out and left in some place close to citrus trees. Even then the likelihood of the establishment of the disease in such trees is not very great. Since no case of canker has been found in Florida since 1927 there would seem to be very little danger of its introduction on citrus fruit from that state.

THE INFLUENCE OF ROOTSTOCKS ON THE TEXTURE AND FLAVOR OF ORANGE FRUITS*

IN the South Australian State Irrigated Experiment Orchard, at Berri, a trial of various citrus stocks was inaugurated in 1913. The stocks used consisted of seedlings of Sweet Orange, Rough Lemon—sometimes called Citronelle—Seville or Sour Orange, Pomelo, and *Poncirus* (Citrus) *trifoliata*—the deciduous orange tree of Japan.

Five plants of each of the above stocks were budded to Washington, Thompson's, Buckeye, Nugget, and Navelencia, as representing navel varieties. Mediterranean Sweet and Valencia Late were used to represent the seed-bearing sweet oranges, whilst Dancy's Tangierine was adopted as the Mandarine type in the trials.

No special attempt was made to secure seedlings from trees of particular merit for rootstocks, but only healthy well-grown seedlings of the various species were utilised in the nursery.

The budwood, however, was all taken from trees, the habits of growth and fruiting of which had been under observation for some years in the State Orchard, at Adelaide, where the work of propagating the trees was conducted. In each instance the same tree yielded the budwood which was used of that particular variety for working over its quota on each kind of stock.

The full range of varieties quoted above as having been worked on Sweet Orange and Rough Lemon stocks was planted out in 1913. Those on Seville and Pomelo rootstocks were set out in 1915, and the final lot, consisting of three trees only of each variety on the Trifoliate orange, was planted out in 1922.

The plot of land devoted to these trials is composed of the very coarse reddish sandy pine ridge loam characteristic of the Murray Valley. It ranges between 2 ft. to 4 ft. in depth over a rubbly marl. The surface is slightly sloping towards the east, and on the whole it is well drained and admirably adapted for citricultural purposes.

At the time of making the juice tests outlined herein the trees on the Sweet Orange and Rough Lemon stocks had fruited over a period of 14 years, with the exception of the Valencia Late, which had borne for 12 years only.

The trees worked on Seville and Pomelo stocks had cropped from 10 to 12 seasons, whilst the whole series growing on the Trifoliate stocks had seven years of cropping recorded to their credit.

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* By George Quin, Chief Horticultural Instructor, Department of Agriculture of South Australia in Bulletin No. 276.

These facts as to the origin and ages of the trees are briefly stated to indicate that at least some of the important factors which might make for varying qualities in the fruits had been much reduced, if not wholly eliminated. Such matters as the relative affinities displayed between the different rootstocks and scion varieties worked on them, or the comparative habits of growth and branch developments, or quantitative yields of oranges are not for the present under review, excepting to remark, in passing, that without exception the trees are normally healthy, thriving, and yielding well.

In planning the research conducted during the orange harvesting season of 1931, trees were selected from which fruits were gathered at fortnightly intervals extending from May 22nd to July 31st in the cases of the Washington and Thompson's Navels, from August 28th to October 23rd in that of the Mediterranean Sweet, and from August 28th, 1931, to February 26th, 1932, the Valencia Late fruits were harvested. The two rootstocks on which the Washington and Thompson's Navel fruits were produced were Sweet Orange and Rough Lemon, whilst those of Mediterranean Sweet and Valencia Late were taken from trees worked on Sweet Orange, Rough Lemon, Pomelo, and *C. trifoliata* respectively.

The procedure adopted consisted of gathering 12 oranges fortnightly from each selected tree. Six of these gauged from 2½ in. to 2¾ in. in diameter, representing the smaller fruits, and the other half dozen gauged 3 in. to 3½ in. in diameter, thus placing them among the larger sizes. As the season advanced it became impossible to adhere exactly to these sizes in so far as the Mediterranean Sweet and Valencia Late sorts were concerned. Owing to the shortage of crop on the selected trees of Mediterranean Sweet worked on both *C. trifoliata* and Pomelo, slight variations and estimates had to be made, which can also be noted in lists containing the working data.

Each orange when cut from the tree had a label enclosed in its wrapper giving full particulars of its origin and grade. The whole series of sizes and varieties were then carefully packed and forwarded to the office of the Horticultural Branch Department, in Adelaide, for testing. The whole of the analytical work and calculations were conducted by Mr. E. W. Pritchard, Agricultural Botanist, who is a skilled analyst and associate of the Australian Chemical Institute. Each half dozen fruits was weighed, and each orange halved equatorially prior to the halves being rotated under hand pressure on a fluted conical glass lemon squeezer until no more juice could be released from the pulp. The juices of the six fruits were then blended and strained through a wire gauze sieve having 24 meshes to the inch, and weighed, thus giving the data for calculating the percentage of juice by weight to the total weight of the whole oranges. As the acids and sugars dissolved in the juicy pulp of an orange are the principal factors which make for a balanced and attractive flavor in the fruit, these alone were determined. The former by titrations with N/10 soda solution, and the latter estimated from readings of the scale on the Brix hydrometer. Using a few drops of phenolphthalein solution in the juice as an indicator of changing color, the number of cubic centimetres of the soda solution required to neutralize 10 c. cs. of the blended juices was determined. If the percentage of acidity as citric acid is desired, it may be ascertained by multiplying the number of c. cs. of the soda solution by ·07.

In addition to the above chemical and physical determinations the texture of the pulp of each lot was recorded by the use of the letters S. for "satisfactory," M. for "moderately raggy or fibrous," and R. for "very raggy or fibrous". A palate test was also used by setting up a scale of impressions indicated as under, V.S. very sour, S. sour, T. tart, T. Mod. moderately tart, Sw. sweet, and V.Sw. very sweet. Each sample of mixed juices was submitted to three or four persons at random for tasting, and the majority agreement recorded as to which term should apply.

The standard of maturity originally adopted in several Australian States was founded on the acidity thus determined from the mixed juices of five oranges selected at random. When not more than 23 c. cs. of N/10 soda solution were required to neutralize the acids in 10 c. cs. of the juice the fruits were deemed to be palatable and wholesome. It was found, however, that fruits containing greater acidity were often made palatable by the presence of a high percentage of sugar in the juice, and conversely oranges with low acidity could, owing to the paucity of sugars in their juices, appear very sour to the palate. Further, when acids and sugars are both very low in the juice the oranges usually become insipid to the taste. In the tests under review this feature was more particularly in evidence in the juices of Thompson's Navel fruits from trees grown on Rough Lemon rootstocks. There may be numerous other reasons for the occurrence of these variations in the proportions of the principal factors which make for palatability in an orange, but the data obtained thus far would seem to indicate that the kind of rootstock used may yet prove a not inconsiderable cause in securing both juiciness and good flavour.

One fact pointed out by other investigators is consistently emphasised by the figures presented in these studies—excepting in those relating to the Valencia Late—and that is, that quite irrespective of variety of orange or of the kind of rootstock used, under ordinary conditions the comparative sizes of the oranges on a tree afford an indication of their respective advances towards maturity. In other words, the juice of an average small orange—up till mid-harvest period at any rate—may be calculated to contain a higher percentage of acid than the large one picked from the same tree and at the same time.

ACIDITY

The fruits of Thompson's Navel, when grown on the Sweet Orange rootstock, displayed appreciably greater acidity than those from trees worked on the Rough Lemon. In the small sized fruits it ranged from the equivalent of 15·6 c. cs. to 12 c. cs., with an average through the testing period of 13·71 c. cs. of the soda solution. In the large fruits a variation of from 16·5 c. cs. to 9·8 c. cs., with a season's average of 13·15 c. cs. was recorded. The fruits of this variety, when worked on the Rough Lemon stock, showed in the smaller sizes a range from 13·8 c. cs. to 9·6 c. cs., with an average of 11·28 c.cs., whilst the large oranges extended from 14·3 c.cs. to 8·9 c.cs., with an average of 11·21 c.cs.

In the case of the Washington Navel on Sweet Orange rootstock, the small fruits extended from 18·2 c.cs. to 12·0 c.cs., averaging 15·3 c.cs., with the large sized fruits showing from 18·7 c.cs. to 11·2 c.cs., or an average through the season of 14·5 c.cs. The fruits of this variety worked

on Rough Lemon ranged in the smaller sizes from 15·3 c.cs. to 11·0 c.cs., averaging 13·18 c.cs., and in the larger sizes from 15·2 c.cs. to 10·4 c.cs., or an average of 13·01 c.cs.

When the data from the small and large fruits of Thompson's Navel worked on Sweet Orange are aggregated their average acidity is equal to 13·43 c.cs., and the oranges grown on trees of this variety worked on Rough Lemon rootstocks averaged 11·25 c.cs. Making similar aggregations of the fruits of Washington Navel grown on Sweet Orange rootstocks an average equal to 14·90 c.cs., and from fruits of this variety grown on Rough Lemon rootstocks the acidity stated in terms of c.cs. of N 10 soda solution is only 13·10. It would appear from the above that the acidity in the fruits from Thompson's Navel trees grown on Rough Lemon stocks is approximately 16·25 per cent. lower than that in fruits of the same variety when grown on Sweet Orange seedling stocks. In the case of Washington Navel the acidity in fruits produced on Rough Lemon rootstocks is calculated to be 12·08 per cent. less than in those grown on the Sweet Orange rootstocks. It will be noted that the first lot examined was not necessarily the most acid in the season's work, neither was the decline in acidity found to follow any regular graduations from fortnight to fortnight, excepting in Valencia Late fruits.

SUGARS (AS SUCROSE)

It will be noticed from the accompanying tables of figures that the total sugar contents of the Thompson and Washington Navel oranges varied only very slightly throughout the 10 weeks from May 22nd to July 31st, though they are consistently higher in fruits from trees of both varieties when worked on the Sweet Orange rootstocks. In all cases, irrespective of variety or stock, the smaller navel fruits consistently displayed a slightly higher percentage of sugar content than was found in the larger sizes.

The average percentage of sugar found in Thompson's Navel fruits of small and large sizes grown on Sweet Orange stocks was 12·24, and when taken from trees on Rough Lemon 11·14 per cent. Washington Navels of both sizes produced on Sweet Orange stocks an average percentage of 11·15, and from similar fruits grown on Rough Lemon stocks the average percentage was 10·85.

JUICE (PERCENTAGE BY WEIGHT OF WHOLE FRUIT)

With one exception in each of the series the percentage of juice by weight to that of the whole fruits was slightly lower in the small sized oranges, but these differences were negligible. In each instance, however, fruits of both varieties carried more juice when grown on Sweet Orange stocks than on the Rough Lemon.

The Thompson's Navels on Sweet Orange stocks averaged 34·80 per cent. as against 33·23 per cent. from fruits produced on Rough Lemon stocks, whilst the Washington Navels displayed averages of 41·75 per cent. on Sweet Orange and 40·65 per cent. on Rough Lemon stocks.

Of the eight series of tests made with these two navel varieties the fruits in five of them, which were gathered on May 22nd, displayed the highest percentage of juice found throughout the series. Of the Thompson's Navel one each of these extra juicy lots was grown on Orange and Lemon stocks respectively, whilst in the case of the Washington Navel two were grown on trees worked on Orange and one on Lemon rootstock.

PALATE DETERMINATIONS

The larger sized fruits of Thompson's Navel grown on trees on Sweet Orange stocks were classed as "sweet" on June 5th, but the smaller sizes did not reach this condition until the third picking on June 19th—a fortnight later.

On the Rough Lemon stocks fruits of this variety, both small and large, were classed as "sweet" on May 22nd.

The larger sized Washington Navels grown on Orange rootstocks were deemed to be "sweet" on June 19th, but the smaller sizes were not classed as "sweet" until a fortnight later, that is, on July 3rd. The smaller fruits grown on Rough Lemon rootstocks were declared "sweet" to the palate when tasted on May 22nd, but were more consistently so four weeks later, when the larger sized oranges were classed as "sweet" on June 19th. It will be seen, therefore, that Thompson's Navel oranges of various sizes taken from trees on Rough Lemon stocks are classed as "sweet" from two to four weeks earlier than when this sort was produced on Sweet Orange stocks.

The Washington Navel fruits from trees on Rough Lemon stocks could be declared consistently sweet on June 19th, and the larger sizes from trees on Sweet Orange stocks from June 19th also, but the smaller sized fruits did not reach this condition until July 3rd—a fortnight later.

TEXTURE OF PULP

The texture of the pulp is gauged from the comparative proportions and coarseness of the "raggy" fibrous tissues which envelop and separate the juice sacs. This ragginess appears to be frequently an evidence of "dryness", or lack of juice in the pulp. In the case of Thompson's Navel fruits—which have an unenviable reputation for developing ragginess—the orange rootstock would appear to exercise an appreciable influence towards the reduction of this undesirable quality in the pulp as compared with similar fruits from trees of the variety when growing on Rough Lemon rootstocks. The pulp of the fruits of Washington Navels, whether taken from trees worked on Sweet Orange or Rough Lemon, in none of these tests were classed other than as "satisfactory," which implies the absence of anything other than normal development of the essential fibrous tissues found in and around the edible pulp of the orange.

Taking the average throughout the season of the acidity, sugar and weight of juices found in the small and large fruits combined, the following table enables a comparison to be drawn between the effects of the two rootstocks on the principal constituents of the Washington Navel and Thompson's Navel oranges:

	Sweet Orange Stocks	Rough Lemon Stocks
Acid—	c. cs.	c. cs.
Washington Navel	14·90	13·09
Thompson's Navel	13·43	11·24
Sugar—	per cent.	per cent.
Washington Navel	11·15	10·85
Thompson's Navel	12·24	11·14
Juice—	per cent.	per cent.
Washington Navel	41·75	40·65
Thompson's Navel	34·80	33·23

THE BETTER UTILISATION OF FORESTS FOR GRAZING*

FOR the Conference of the Animal Husbandry Wing of the Indian Council for Agricultural Research held in Delhi in February, it was originally intimated that the title of this article would form an item of the agenda, and steps were taken to have the Forest Department represented at the discussion, but unfortunately it was subsequently omitted and an excellent opportunity has thus been lost for demonstrating to those interested what is being done by the Forest Department in various parts of India to help the *zamindars* and villagers in their grazing problems. The following notes have been collected with the object of summarising the present position :

Statistics of Forest Grazing.—Out of the total land in the charge of the Indian Forest Department (225,000 sq. miles) over half (124,000 sq. miles) lies in Burma, where the grazing question is of minor importance owing to the sparseness of the population. We are chiefly concerned with the remaining 100,000 sq. miles in India proper. Out of this total forest area, practically 80,000 sq. miles are open to grazing but the incidence of grazing varies enormously. The higher Himalayan forests are practically unused, and the great belt of forest along the foot of the Himalayas in Bengal and United Provinces is out of reach of the cultivators; in fact, out of 41 million head of cattle in U. P. only one million, or 2½ per cent., make any use of forest grazing areas. In the Punjab the foothills belt is much more densely populated and thus the forests are much more heavily grazed. In the Central Provinces, Bombay and Madras, also, the agricultural population makes greater use of the forests, which are here interspersed among cultivation. Even so, grazing is generally confined to the outer fringes of each forest block, so that figures of general incidence do not give any true indication of the tremendously heavy incidence which occurs in many localities. The value of grass and grazing obtained from forests free or at concession rates varies from over Rs. 20 lakhs in the Punjab for less than 7,000 sq. miles of forest, to less than Rs. 20,000 in Assam for 20,000 sq. miles.

Extent of Problem.—It must be remembered that the forest grazing problem is only one part of the much larger problem of Indian animal husbandry as a whole, and that the obvious remedies indicated by the Royal Commission on Agriculture for the general improvement of farm animals and the means of feeding them, apply equally to communities dwelling in or near forest tracts. There are, however, additional considerations applying to the interaction of grazing and forest management which make it all the more essential that the vast numbers of excess cattle maintained by most village communities living near forests should not become a drain upon forest resources.

* From the "Indian Forester," Volume LIX, No. 3, March, 1933.

Most of the early forest settlements were so liberally framed that no check can be exercised under them upon the number of animals which can graze in a given forest area, and with the phenomenal growth of population and of live-stock under the protective influence of British rule, what was originally a reasonable privilege to graze a few head of cattle has now grown into an intolerable burden or over-grazing, which not only ruins any chance of improving the forest silviculturally, but in many cases is leading to active erosion and the eventual disappearance of any vestige of woodland or even of grassland.

Classification of Grasslands according to Rainfall.—The Agricultural Department has proved by practical demonstrations that while continuous, unlimited, and uncontrolled grazing creates definite deterioration, grazing in itself, when properly regulated, is not necessarily an evil even in intensively managed timber forests. Even intensive grazing, provided it is properly controlled and not continuous, will allow the vegetation to follow out its natural progress towards an ecologically higher type of plant community. But the actual amount of grazing which will not interfere with such progress depends largely upon the amount and distribution of the rainfall. We can thus classify all forest grazing grounds into one of two classes which are separated roughly by the 50 inches of rainfall mark.

In the heavy rainfall class with anything over 50 inches, the natural vegetative cover which tends to develop is some form of dense tree forest, in which grassland is sooner or later ousted by tree growth, and if grasses occur, they tend to be large perennials of coarse and fibrous texture. In such conditions any attempt to improve the grazing quality of open forest or scrub land must involve interfering with the natural tendencies of nature by delaying the advance of denser jungle. Timber production and grazing improvement are therefore incompatible in such areas.

In the areas of light or deficient rainfall, however, things are quite different. Here grasses rather than trees form the major part of all natural crops in all stages of development, and even the ideal or climax forest generally contains a large amount of grass. Moreover, the highest species of grass in an ecological sense are also the most valuable for feeding purposes, because leafy annual grasses are not, as a rule, ousted by the coarser perennial fibrous ones on such sites. In the dry zone the best fodder is, as a rule, found on the damper sites. Maltreatment by continuous overgrazing will inevitably throw such areas back to a less valuable fodder type as well as causing deterioration of the forest, while better utilisation of the fodder is synonymous with better forest management. It is in such areas of light or deficient rainfall that Dr. Burns' illuminating experiments on grazing in Bombay have been made, and it is obvious that it is in such areas that the Forest and Agricultural Departments can best co-operate in demonstrating better utilisation of forest grazing.

Findings of the Roval Commission on Agriculture in India.—The recommendations having a direct bearing upon the forest grazing problem were as follows (page 276 of Commission's Report):

1. Grass cutting should be encouraged as an alternative to grazing.
2. The grazing of inferior cattle in the forests should be discouraged.

3. The intensity of grazing consistent with the proper development of the forest and the preservation of desirable grasses should be determined as soon as possible.

4. Forest areas in each Province should be classified with a view to determining which are most suitable for the growth of timber, for preservation under forest on physical grounds, or for development as fodder reserves and grazing grounds.

Of these, Nos. 1 and 2 are largely dependent upon the wider question of the improvement of stock as a whole. The Forest Department cannot progress far in substituting grass cuttings for grazing unless and until the villagers have cattle for which it is worth cutting grass. Even partial stall-feeding is only worth while for picked animals and is out of the question for large herds of semi-starved animals. Similarly the grazing of inferior cattle in forests cannot be discouraged actively until the large problem of reducing the numbers of surplus cattle has been taken in hand.

No. 3 and 4 also seem to be rather superfluous until more practical steps have actually been taken to reduce the incidence of grazing where it is obviously excessive. There is little point either in knowing the proper intensity of grazing for any given site, or in segregating land for timber production, when the whole of a forest is in actual fact deteriorating rapidly through overgrazing.

SUMMARY OF POSITION IN DIFFERENT PROVINCES

Assam.—No large scale fodder operations have been undertaken, and taken as a whole, the grazing problem is not acute. Substitution of grass cutting for grazing is not possible, but the influx of grazers from outside the Province has rendered necessary the reservation of grazing grounds for local needs. Where there is local demand for fodder, arrangements have been made to set aside portions of Unclassed and Reserved Forests for grass cutting.

Bengal.—In Northern Bengal the combination of grazing with profitable forestry is impracticable owing to the denseness of the forest growth. A great advance in encouraging stall-feeding has been made by building *bathans* (cattle sheds) at Government expense and charging only a nominal rate for cut fodder. This was very unpopular at first but the graziers are now beginning to see that their cattle are improving, and are in places applying to be allowed to build their own *bathans*.

In Southern Bengal there is of course no grazing whatever in the Sundarbans. In the remaining forest divisions, available grazing grounds have been invaded by *Eupatorium,* whose shrub growth kills out the grass. Proposals for the transfer of certain *khas mahal* forests to the Forest Department are under consideration, but it would be preferable to run them as grazing grounds rather than attempt to exploit the scanty forest growth they contain. Villagers would have to undertake the cutting back of *Eupatorium* and the planting of "African grass" which have been favourably reported on by the Agricultural Department. In the Chittagong Hill Tracts all cultivation is shifting, and here again all abandoned cultivation is invaded by *Eupatorium.*

Bihar and Orissa.—Government forests here are only 3 per cent. of the Province and are true forests with no natural grassland. Where grazing is allowed it is governed by rotational closures under the working plans.

Bombay.—Much work has been done by the Agricultural Department here in grass improvement, particularly in the dry tracts, proving clearly the need for fencing, limitation of head of cattle, prevention of grazing during early monsoon, provision of watering facilities, and tree planting for shade. The Forest Department as tenant of a large portion of the true grazing land has co-operated in this work and has already arranged for proper grazing rotations and facilities in several of their Working Plans, notably that for Jumner. Special areas for grass cutting are reserved for local users where this is necessary. The Grazing Rules provide for the limitation of head of cattle by the Collector, but this has never been made use of, and excessive grazing is almost universal, to the detriment of both the stock and the grazing grounds. The problem is particularly serious in Bombay Presidency's dry tracts.

Burma.—As explained in the introductory notes, the question of grazing improvement is a minor matter in Burma, and this province may be omitted altogether from the discussion.

Central Provinces.—Although there are large areas in the 19,000 square miles of Government forest which are not grazed at all, an immensely heavy incidence occurs in all fringes of forest adjoining cultivated areas. The cultivators in such places take no steps to reduce the size of their herds, which are only thinned out periodically by famine years. The cultivators who live beyond reach of any forest, on the other hand, keep only such cattle as they can keep properly fed. Unfortunately the chance of improving the local breed in non-forest areas is spoilt by the fact that all replacements are made from purchases of the cheap and underbred animals from the forest fringe herds.

The regulation of forest grazing is done under all working plans because approximately 80 per cent. of Government Forests and nearly all private ones are classed as pasture land in which, according to the Royal Commission on Agriculture, the preservation and improvement of pasture should be the primary object of management. Revisions of plans are scrutinised by a specially appointed revenue officer who tours the tract in the company of the forest working plans officer and discusses the draft prescriptions which are to affect the grazing with him. The officially accepted incidence is 3 acres per head, but this is often reduced, as the revenue officer frequently finds that there is not enough grazing for the existing cattle and therefore prescribes a higher incidence. If the working plan officer protests he is told that the forest is not classed as a tree forest. It is generally recognised that the incidence should be very much lighter on light sandy soils, but no figures are available in support of this. Many of the best fodder grasses are annual, and if heavily grazed, they are ousted by the coarser perennial grasses or shrubs such as *Cassia tora,* and heavily grazed areas can only be saved from deterioration by periodic closure, and by a drastic reduction in the useless herds of forest fringe grazers.

Experiments are in progress in several forest divisions to determine the best method and season in which to harvest the grass crop from various types of forest land, comparing fertile valleys with the higher waterless

tracts, and also to determine the permissible grazing incidence for such types. From results to date it appears that very lengthy closures do not bring about any cumulative improvement in the grass crop after the third year of closure. Local experience also tends to show that at any rate on trap soil some grazing is indispensable in securing the natural regeneration of teak.

It can thus be seen that the whole silvicultural prospects of the Province are bound up in the successful reconcilation of the conflicting claims of pasture preservation and the production of the vast quantities of poles and fuel wood which are equally essential for the welfare of the C. P. agriculturists.

Madras.—The forest grazing problem in this Presidency is complicated by the fact that the heaviest incidence falls upon the *panchayat* forests which adjoin the villages more closely than the reserves do. The Forest Department has no data whatever for the *panchayat* forests, and absolutely no control over them as they are entirely separate from the forest administration. All we know is that there is almost universal deterioration owing to excessively heavy and unregulated grazing. This also applies to reserves, but to a lesser extent because in most working plans some attempt has been made to provide for closure at least for forest regeneration work. 12½ per cent. of forests under the Forest Department have some form of closure applied to them. The grazing incidence in reserves is nominally 5·5 acres per head, but in populous districts (*e.g.*, Lower Godaveri) it falls to 2 acres for the district, which represents an enormously heavy incidence in the fringe of forest adjoining cultivation. The Chief Conservator of Forests recommended in 1920 that a reduction of grazing should be effected by the enhancement of grazing fees and that grazing in reserves should be controlled by forest blocks instead of by ranges—*i.e.*, reducing the size of the control unit. This, however, was not accepted by the Government, and the result is that the damage and deterioration from over-grazing in the drier parts of the Presidency are becoming rapidly worse.

Punjab.—It has been fully realised for many years past by all forest officers in the Punjab that very rapid and widespread deterioration was taking place in almost all the foothill forests through over-grazing. Several papers and publications have emphasised this. The historic examples of the Hoshiarpur *chos,* and the denudation and erosion which are rapidly ruining the grazing value of the foothill grazing grounds, are undeniable facts which are only slowly penetrating to the notice of a wider public. Unfortunately very little can be done until public opinion has come in on the side of regulation and restriction of grazing, and legislators dependent upon popular vote will not risk a loss of popularity by taking up restrictive measures. We as forest officials know fully well what is required, but there is no possibility of carrying out what is necessary unless and until the grazing communities of the foothills can be persuaded to try restriction of grazing in their own interests. Meanwhile widespread deterioration goes on apace and gets obviously worse each year that proper management of the grazing grounds is delayed.

United Provinces.—Out of 41 million head of cattle in the Province, only one million makes any use of forest grazing. In the U. P. forests, grazing forms only a small part of the larger problem, for there is far more need for grazing regulation in the 25,000 square miles of other waste lands than in the 5,000 square miles of reserved forest. The amount of denudation and erosion going on at present in many of the plains districts such as Etawah is appalling, and is very largely due to over-grazing on land which is peculiarly vulnerable to damage once the original mat of herb covering has been destroyed.

It has been definitely proved that a supply of good fodder grasses can be much improved in *usar* and ravine lands by simple closure to grazing and substituting grass cutting, or restricting the grazing to definite periods. Improvement of grazing in the reserved forests has been prescribed in several of the current working plans, *e.g.*, cutting back thorny plants usurping grasslands and introducing better fodder grasses.

THE RICE CROP IN BURMA*

HISTORY

NO records are available of the extent of paddy cultivation in Burma before the 19th century, but there is little doubt that the crop has provided the staple food of the inhabitants of Lower Burma at least from earliest times, as rice is considered to be indigenous to that part of south-eastern Asia in which Lower Burma is situated. It has also no doubt been cultivated in Upper Burma for many years, and the early irrigation systems there were started in the vicinity of the Burmese Courts.

Before the third decade of the 19th century and the British connection the crop was cultivated for home consumption only, and there was no export trade, except in small quantities from Arakan. The Arakan Division, Amherst, Tavoy and Mergui Districts of Tenasserim came under British rule in 1825, and the remainder of Lower Burma which includes the Pegu and Irrawaddy Divisions, and the Thaton, Salween, and Toungoo Districts in 1854-55. Upper Burma came under British control thirty years later in the year 1885.

At the different times the various tracts of Lower Burma came under British control, the extensive plains on which paddy is now cultivated were mainly swamps, covered with forest vegetation and sparsely populated, the inhabitants living in small scattered hamlets, and subsisting on fishing, salt boiling, and shifting paddy cultivation in clearings. There was little or no trade in rice except for barter in exchange for other commodities of life.

In 1830, the area under paddy was about 66,000 acres in Arakan, and about 40,000 acres in Amherst, Mergui and Tavoy Districts. In 1855 it had increased to 350,000 acres in the former and to 180,000 in the latter, and Akyab exported about 200,000 tons of paddy per annum.

In 1855 the area under paddy in the Pegu and Irrawaddy Divisions, and the Thaton, Salween, and Toungoo Districts was about 563,000 acres, giving a total for the whole of Lower Burma of 993,000 acres, or about one-tenth of the area now under cultivation there.

The great extension that has taken place since that date is due mainly to the establishment of a settled Government in the country, without which the capital that was necessary to develop the land and build up a rice trade could not have been obtained.

Land Policy.—The policy of Government was to make it as easy as possible for the people to take up land in Lower Burma, and immigration from Upper Burma and India was encouraged on account of the sparseness of the population in Lower Burma. Cultivators who took up land acquired Landholders' Rights over it after the continuous payment of Land Revenue

* By J. W. Grant, M.A., B.Sc., I.A.S., Deputy Director of Agriculture, Burma, in Agricultural Survey No. 17 of 1932.

for a period of 12 years. Up till 1860 the number of immigrants was small, and they came mainly from Upper Burma, but after that date increasing numbers came from India. The majority of the Indian immigrants however were labourers, and although some of them settled on the land the numbers that have done so are comparatively small.

After the general rise in prices that took place about 1870, settlers began to pour in in large numbers from Upper Burma, while at the same time the Madras Chettyars began to arrive in increasing numbers as there was a demand for the capital they could supply, and the security they could obtain was good. The majority of the present day paddy cultivators of Lower Burma are therefore the descendants of the original inhabitants and of immigrants from Upper Burma, and a few descendants of Indian settlers.

A feature of the history of paddy cultivation in Lower Burma in contrast with that of the older rice-producing countries of the east is that almost the whole of the area has been brought under cultivation during the last 60 years by small cultivators producing for an export market, the work having been financed mainly by Madras Chettyars. In Upper Burma extension is due mainly to irrigation works carried out by Government.

Communications.—Before the British connection Burma was practically roadless and nothing more than jungle tracts existed. Communications were therefore mainly by waterways by means of slow-moving country craft. From 1860 onwards communications were steadily improved. In 1868 the Irrawaddy Flotilla Company started operations on the inland waterways of Lower Burma, and in the course of the next 10 years had built up a fleet of 29 steamers and 40 flats which has steadily increased till the total number of craft operated by the Company over all the main waterways in Burma is now about six hundred. Within recent years smaller companies have started operations and communications by all inland waterways are now good.

Roads and railways were constructed, the first railway line to be opened being the Rangoon-Prome line in 1877. The line to Toungoo was completed 8 years later, and this was followed by the line to Mandalay in 1894, and the Mu Valley Section in 1899.

Since that date road and railway construction has continued, the most important railway extensions so far as paddy cultivation is concerned being the Pegu-Moulmein Branch with its extension to Ye and the Letpadan-Bassein Line with its branches connecting the rice-growing districts of the Irrawaddy Division with Rangoon.

Between 1870 and 1900 the Twante Canal was improved, the Pegu-Sittang Canal and the Pegu-Kyaikto Canals were cut in order to provide inland waterways for country boats and small steamers.

Embankments and Canals.—In Lower Burma embankments are necessary in some tracts for the protection of crops against floods and canals are required either for communication or for drainage purposes. In Upper Burma canals are needed for irrigation only.

In 1880-81 the Maubin Island Embankment protecting 140,000 acres was completed. In 1881-82 the Kyangin, Myanaung, and Henzada sections of the Irrawaddy embankments, protecting an area of 630,000 acres were completed, and this was followed by the completion in 1887-88 of the Sangyin-Sagaggi section, protecting 30,000 acres and the Thôngwa Island section protecting 40,000 acres, in 1896.

In 1883-84 the Sittang Embankment protecting 40,000 acres was completed and the work connected with the Pegu-Sittang Canal opened in 1887-88 incidentally protected an area of 30,000 acres. In 1922-23 the Thôngwa Island Embankment protecting 63,000 acres was completed and this was followed by the completion in 1925-26 of Tamatakaw Embankment in Pyapôn District protecting 14,000 acres from salt water inundation.

In Upper Burma, the Burmese irrigation systems were improved from 1890 onwards and major works were also undertaken. In 1902 the Mandalay Canal irrigating 90,000 acres was opened, and this was followed by the opening of the Shwebo Canal in 1906, and the Môn Canal in 1911, the areas irrigated by these two canals being 290,000 and 70,000 acres respectively. In 1918, the Ye-u Canal irrigating 90,000 acres was opened. In addition to the above major works, embankments and small canals of local importance have been made by cultivators, aided in most cases by loans under the Land Improvement Act.

These figures show that the extension of paddy cultivation has taken place mainly in Lower Burma and it is in Lower Burma that the paddy industry of the country has been built up, as the Upper Burma crop is all required for local consumption. From 1855 onwards the area increased rapidly, but it was about 1870 that the most rapid extension began. Between 1860 and 1870 the area increased by about 400,000 acres, and during each of the following two decades the area in Lower Burma extended by about 1,300,000 acres. From 1890 onwards the figures apply to the whole of Burma, and the increase during the next 10 years was over two million acres in Lower Burma and 600,000 acres in Upper Burma. Between 1900 and 1910, the rate of increase was less than during the previous two decades and although the best of the land had been taken up by this time 1¼ million acres were brought under cultivation in Lower Burma during that period. From 1910-20 the area under paddy increased slightly, the total area under cultivation being about 10⅓ million acres. On account of the very high prices ruling for paddy after 1920 a further two million acres were brought under cultivation between that date and 1930. Much of the land that was brought under cultivation during this period consists of accretions on the sea coast, and low-lying areas that can only be cultivated with deep water paddy, and as the crops on many of these are liable to be destroyed wholly or partially by flooding they can only be cultivated profitably when paddy prices are high.

Prices.—In 1840 the price of paddy in Rangoon was Rs. 8/- per 100 baskets as there was no market for it at this time and it rose from Rs. 12/- in 1850 to Rs. 45/- in 1855. In 1860 the price was about Rs. 50/- per 100 baskets and it rose to about Rs. 70/- in 1870. In 1880 the price rose to about Rs. 100/- and it fluctuated round about Rs. 90/- and Rs. 95/- till 1900, although at various periods it rose much higher on

account of scarcity in India, and it is recorded that the price was as high as Rs. 195/- at one period in 1877 on account of famine there. The bulk of the paddy land in Lower Burma was reclaimed during the period from 1870 to 1900 and the price ranged round about Rs. 95/- per 100 baskets. From that time onward till 1914 there was a general rise in prices to about Rs. 130/- but after a few years of fluctuating prices at the beginning of the war, prices rose to about Rs. 190/- or more in 1920, and remained about the same level for the seven following years when there was a general decline to Rs. 130/- in 1930. In 1931 due to world-wide trade depression the prices fell to about Rs. 75/- per 100 baskets, but at the time of writing (February 1932) they have risen slightly to Rs. 100/-. The most important external factor that influenced the rapid extension of paddy cultivation and prices was the general development that took place all over the east, as a result of the opening of the Suez Canal in 1870, the improvement of steam shipping about the same time, and the extension of banking.

At first the European market was the most important but there has been an increasing demand for Burma rice to feed labourers employed in plantations and employed in industry in the east, as well as in Africa and the West Indies, and at the present time the eastern market is by far the greatest. The rice-milling industry developed rapidly to supply the demand for rice, ships were available for transport, and capital was provided for the movement of the crop.

On this account the cultivator has for the last 80 years had a ready market for all the paddy he could produce, and as there has been a steady increase (apart from small fluctuations) in prices throughout the period the circumstances have been very favourable for the rapid expansion that has taken place. The best of the paddy land however has already been taken up, and increased production in the future will have to depend on better farming rather than extension of the area under cultivation, as the time appears to have arrived when extensive methods of cultivation can no longer be applied to increase production.

CONFIGURATION, CLIMATE, SOILS AND RICE-GROWING TRACTS

Configuration.—The greater part of Burma which extends from latitude 10°N. to 27°N. lies within the tropics. To the north there is a tangled mass of mountains from which three main ranges spread out towards the south. From the north towards the south-east the Sham range extending almost to the south of Tenasserim Division forms the eastern boundary of the country. From the north to the south-west there is the Arakan range cutting off the Arakan Division from the rest of Burma. Between these two, there is the smaller Pegu range dividing the country into two halves. The Irrawaddy River which is navigable for 900 miles from the sea, the Salween River, and the Sittang River, all of which flow more or less due south are the main drainage channels of the country. The low-lying delta lands and the coastal plains are intersected by innumerable tidal creeks many of which are navigable, and it is in these lands that the bulk of the paddy crop is produced.

Climate.—Burma has essentially a monsoon climate and is entirely dependent on the south-west monsoon for its rainfall. The rainy season lasts from about the middle of May till the middle of October. The remainder of the year is almost rainless, and the few showers that fall during this period are of no agricultural value.

In the table below, is shown the monthly rainfalls recorded at typical Agricultural Stations in Lower Burma and in Upper Burma, Akyab and Mudong being typical of the tracts of heavy rainfall in Arakan and Tenasserim respectively, Hmawbi of the remainder of Lower Burma, and and Mandalay of the Upper Burma dry zone.

	Hmawbi	Mudong	Mandalay	Akyab
	(Inches)	(Inches)	(Inches)	(Inches)
January ...	0·06	0·04	—	0·12
February ...	0·01	0·01	0·15	0·02
March ...	0·22	0·71	0·11	—
April ...	1·92	6·50	1·45	2·32
May ...	8·23	21·60	3·89	14·64
June ...	18·66	41·68	4·63	48·57
July ...	23·69	60·69	2·91	74·78
August ...	19·46	37·70	3·07	56·68
September ...	14·34	1·33	5·90	21·68
October ...	6·85	4·08	6·75	17·45
November ...	1·05	1·05	3·10	3·67
December ...	0·10	0·01	0·23	1·16
Total ...	94·59	195·40	32·19	241·11

The country may be divided into three climatic zones.

Lower Burma Wet Zone.—In the south there is the Lower Burma wet zone covering roughly the Pegu, Irrawaddy, Tenasserim, and Arakan Divisions. This zone receives directly and almost without interruption the rains brought by the south-west monsoon from the middle of May till the middle of October. The annual rainfall which in this tract is fairly constant from year to year in any given locality varies from 70 to 100 inches in the Pegu and Irrawaddy Divisions. In the Arakan and Tenasserim Divisions (excluding Toungoo District) which are exposed to the full effects of the monsoon the rainfall is much higher, and varies from 180 to 200 inches per annum, although 300 inches have been recorded. During the monsoon period, the temperature ranges round about a mean maximum of 95°F. and a mean minimum of 75°F. During the dry season there is a short cool spell in December and January with a mean maximum of about 85°F. and a mean minimum of about 65°F. This is followed by a hotter period extending to the middle of May during which the mean maximum is about 98°F and the mean minimum 76°F.

Upper Burma Dry Zone.—To the north of this zone lies the dry zone of Upper Burma, comprising mainly the Magwe and Mandalay Divisions together, with Sagaing and Lower Chindwin Districts of the Sagaing

Division where the rainfall varies from 30 to 40 inches per annum. During the rainy season from May till October the temperature ranges round about a mean maximum of 85°F. and a mean minimum of 75°F. During the dry season the mean maximum and minimum temperatures from the middle of November till the middle of February are about 80°F and 65°F. respectively but this comparatively cool spell is followed by a hot period till the middle of May during which the mean maximum is about 100°F. or more and the mean minimum 76°F.

Northern Wet Zone of Upper Burma.—Beyond the dry zone there is the small northern wet zone of Upper Burma situated in hilly country comprising mainly the Bhamo, Myitkyina, Katha and Upper Chindwin Districts of the Sagaing Division. Here the rainfall varies from 70 to 80 inches per annum. During the rainy season the temperature in the plains is much the same as in the Lower Burma wet zone, and during the dry season it approximates to that of the dry zone though considerably cooler on the whole.

Soil.—The paddy soils throughout the country are mainly alluvial. In Lower Burma they are almost entirely old alluvium, and they are situated in the low-lying plains of the delta and lower reaches of the Irrawaddy River and its tributaries, in the plains along the lower reaches of the Sittang and Salween Rivers and their tributaries, and in the alluvial coastal plains of Arakan and Tenasserim. The paddy soils in Lower Burma may be classed as fairly heavy clays or clay loams with a stiffer subsoil, overlying at greater depths slaty blue clay, sand and gravel. During the dry season they crack and bake so hard that cultivation is only possible at the break of the monsoon. They are rich in potash and generally deficient in nitrogen and available phosphate, but they are on the whole well suited for the cultivation of paddy under the conditions prevailing in that part of the country where the land is submerged for the greater part of the monsoon.

In Upper Burma, paddy is cultivated mainly in low-lying areas where the water collects in the rainy season, and on areas that can be irrigated. The bulk of the crop is cultivated on alluvial soils which though they show greater variation in texture than the Lower Burma soils may be classed as clays. These soils are difficult to work until they have been saturated with water and the heavier types are even more sticky than the Lower Burma soils, as they generally contain a higher percentage of clay and less silt. These soils are rich in potash and generally deficient in nitrogen and available phosphate, and differ mainly from the alluvial soils of Lower Burma in that they are alkaline, while those of Lower Burma are acid. In the table below are shown the analysis as carried out by the Agricultural Chemist, Burma, of soils from Agricultural Stations in Lower Burma and Upper Burma. These are fairly typical of the soils of the tracts in which they are situated.

ANALYSIS OF SOILS FROM AGRICULTURAL STATIONS CARRIED OUT BY AGRICULTURAL CHEMIST, BURMA

Mechanical Analysis

	Lower Burma (rainfed paddy)				Upper Burma (Paddy under irrigation)
	Annual rainfall 96 in.-100 in.		Annual rainfall 200 in.		Annual rainfall 30 in.
	Hmawbi Agricultural Station	Myaungmya Agricultural Station	Akyab Agricultural Station	Mudon Agricultural Station	Mandalay Agricultural Station
Gravel and Stones	—	—	·04	—	—
Fine Gravel	—	—	·151	—	8·0
Coarse Sand	3·9	7·3	48·371	5·07	4·11
Fine Sand	2·9	10·0	16·15	17·90	18·17
Silt	33·1	24·0	12·87	21·40	12·75
Fine Silt	43·5	40·6	13·75	33·81	16·06
Clay	9·1	14·8	6·60	15·92	40·20

Chemical and Physical Analysis

	Lower Burma (rainfed paddy)				Upper Burma (Paddy under irrigation)
	Annual rainfall 96 in.-100 in.		Annual rainfall 200 in.		Annual rainfall 30 in.
	Hmawbi Agricultural Station	Myaungmya Agricultural Station	Akyab Agricultural Station	Mudon Agricultural Station	Mandalay Agricultural Station
Insoluble Residue	63·87	72·19	90·74	80·42	69·79
Soluble Silica	15·26	—	—	—	—
Ferric Oxide Fe_2O_3	3·63	4·19	2·55	2·86	4·48
Aluminia Al_2O_3	10·07	9·74	2·14	6·88	10·45
Lime CaO	0·29	0·12	0·13	0·12	1·38
Magnesia MgO	2·29	0·46	0·43	0·26	1·00
Potash K_2O	0·57	0·27	0·07	0·35	0·71
Soda Ma_2O	0·36	0·17	0·16	0·13	0·28
Sulphuric Acid SO_3	0·08	0·12	0·10	0·04	0·02
Phosphoric Acid P_2O_5	0·03	0·03	0·03	0·06	0·05
Carbon Dioxide CO_2	0·02	0·11	0·05	0·05	0·52
Organic matter and combined water	5·53	8·07	2·53	6·38	5·82
Manganese Oxide Mn_3O_4	—	0·06	0·06	0·01	0·02
Organic Carbon	—	2·234	0·064	1·866	0·42
Organic Nitrogen	0·72	0·171	0·07	1·1412	0·035
Available P_2O_5	0·0029	0·0024	0·0021	0·0091	0·0068
Available Potash K_2O	0·0147	0·0092	0·0098	0·0056	0·0192
pH Value Acidity-alkalinity	6·1	5·5	(Acid)	5·5	8·05

Rice-growing areas.—The main physical factors that have determined the distribution of paddy cultivation in Burma are rainfall and soil, as it is a crop that requires a large amount of water, and the soil, and sub-soil must be sufficiently close in texture to enable water to be kept on the fields to a depth of 3 to 6 inches throughout the growing season.

As shown from the Season and Crop report for Burma for the year ending June 1931 and the total area under paddy amounted in that year to 12,369,566 acres. Over 80 per cent. of the crop is produced on the stiff alluvial clay soils of Lower Burma where the crop is almost entirely rainfed, and it is from Lower Burma that the whole of the exportable surplus comes. In Upper Burma, about one-half of the total crop is grown under irrigation from Government canals and tanks. In the Mandalay, Kyauksè, Minbu, and Meiktila Districts the greater part of the crop is grown under canal irrigation. In Shewebo which is the most important paddy district in Upper Burma, and in the Yamèthin District, about half of the crop is grown under irrigation. In Pakôkku, Sagaing, Bhamo, Katha and Upper Chindwin Districts about two-thirds of the crop is rainfed. In the Thayetmyo, Lower Chindwin and Myitkyina Districts, the crop is almost entirely rainfed.

In addition, upland paddy (Taungya paddy) for which no records are available is cultivated in small patches here and there in the uplands throughout the greater part of the country, but this crop is comparatively unimportant, as it is used for local consumption only.

THE HOUSE FLY*

THE house fly *Musca domestica* Linn., may be rated amongst the most common insect associates of man, but familiarity with this insect has been accompanied by a corresponding ignorance of and indifference to the dangers to health that are associated with its presence. However, there is now an awakening to this danger the reality of which is indicated by the fact that the names "disease carrier" and "typhoid fly" have been suggested as substitutes for the somewhat innocent-sounding name of "house fly". This article discusses briefly the life-history and habits of the house fly, and points out the various recognised measures which may be adopted for its control.

DISTRIBUTION

The house fly is widespread throughout the world; it is present in every continent, and has been found not only in the tropical and temperate zones, but even in subpolar regions such as Lapland and Finland. Not merely is the fly widespread, but, given suitable conditions, it is capable of breeding to enormous local populations.

LIFE-CYCLE STAGES

The eggs are tiny white objects, somewhat banana-shaped and about one-twentieth of an inch in length.

The larva or maggot is slender, white, and shining, and is about one-twelfth of an inch long when it hatches. The body thickens from a narrow-pointed head to a blunt and rounded anal segment. When full grown the length has increased to almost half-an-inch, and the colour gradually changes to a creamy shade. During the growth period the larva moults twice.

The pupal stage of the insect is passed within the final larval skin, which envelopes the insect and contracts and hardens into a cylindrical-shaped puparium with rounded ends. The colour deepens to dark-brown. The puparium is approximately one quarter of an inch in length.

A detailed description of the adult fly is rendered needless. It is necessary to refer to only a few structures. The mouth-parts are wonderfully complex, with a proboscis capable of extrusion for the purpose of sucking liquid food. It is incapable of piercing or chewing, but solid food such as sugar is first dissolved by a flow of saliva and the resultant solution is then sucked up.

The tarsal joints of the legs constituting the feet are well adapted for walking either vertically or upside down on smooth surfaces. The terminal joint has, besides two claws, two sticky pads covered with very fine hairs and furnished with glandular openings from which there exudes a sticky fluid.

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* By J. A. Weddel, Assistant Entomologist in Queensland Agricultural Journal, Vol. XLI, Part I, 1 January, 1934.

The legs and body of the fly are clothed in fine hair-like spines which make the lodgment of contaminating particles almost inevitable.

LIFE-HISTORY

The eggs are laid in batches of about 110 to 150 eggs, in fresh manure, garbage, faeces, and decaying vegetation. They hatch usually in from 8 to 24 hours, the time varying with the temperature.

The larvae or maggots may be found in squirming masses within a few inches of the surface of infested material, but if the material is soft and moist and not subject to excessive internal heating, the maggots may penetrate throughout. At the end of about five days in warm weather the maggots achieve full growth, and they move then to a suitable spot in which to pupate, the ideal site for pupation apparently being moderately damp soil giving easy penetration. Pupation may occur at depths varying from little more than 1 inch to 2 feet, the latter being recorded in sandy loam.

The pupal period lasts approximately three to five days in warm weather, but great variation in this period may occur according to the temperature conditions, development being slower with low temperatures.

This period constitutes the time during which the marked change from larve to adult is taking place, and it is terminated by the complete development and the emergence of the adult insect. The adult fly commences to feed soon after emergence, but egg-laying does not occur until after a lapse of ten days to a fortnight. It will be seen that a complete generation from egg-laying to egg-laying may occupy only a little over three weeks in warm weather.

HABITS AND MENACE OF THE ADULT FLY

In the matter of food, the house fly has most varied tastes; moist garbage and horse manure are just as attractive as man's most carefully refined food. Further, it is essential for the fly to visit putrefying material in order to lay its eggs. As has been pointed out, contaminating material will be caught in the hairs clothing the body, and on the claws and sticky pads of the feet, and on the extruded tongue. These, taken together, constitute only one section of the danger, however. It has been definitely proved that viable bacteria capable of causing human diseases, such as typhoid and tuberculosis, among many others, may be recovered from the alimentary canal of the house fly several days after infection. This means that the familiar fly specks are potentially infective material.

NATURAL CONTROL

The fluctuations in the number of flies are largely due to variations in temperature. The high summer temperatures induce rapid breeding, and if they are accompanied by high humidities, then the breeding sites are kept suitably moist. Low temperatures increase the length of the developmental period, thus slowing up the rate of breeding, and at the same time rendering sluggish the adult flies that are present.

The house fly is subject to attack by parasitic organisms, the most notable being the fungus *Empusa muscae* Cohn. The spores of this organism give rise to a growth of white fungus which ramifies and distends

the body of the insect. Swollen, sluggish, and dead house flies will probably often have been observed by householders. The effects of the fungus are most marked in the late summer and autumn months, when large numbers of the flies are killed in this manner.

Spiders, and various predatory insects such as mantids, robber flies, and wasps of various families, all take their toll of the adult house flies.

The eggs, larvae, and pupae are liable to attack from insects such as ants and ground beetles.

ARTIFICIAL CONTROL

The artificial control of the house fly and the elimination of danger from it may be take a threefold from: (*a*) Exclusion; (*b*) elimination of breeding sites; (*c*) destruction of the adults.

EXCLUSION

Infants and patients should be protected from the attentions of flies by mosquito nets or other comparable means of exclusion. Foodstuffs and cooking utensils should be adequately covered and suitable gauze-screened cupboards should be provided for fresh foods. Infants' food, feeding bottles, milk, and so on should be most carefully protected. In cases of severe and more or less permanent infestation of buildings by flies serious consideration should be given to the complete screening of all doors and windows.

ELIMINATION OF BREEDING SITES

With the growth of motor transport, the number of stables in city areas tends to decrease, and in those that remain the breeding of flies is now less possible than formerly because stable owners must take suitable precautions to prevent accumulations of manure.

There are, however, instances where manure must be stored for short periods, and it has been found that heaps of manure, if closely packed, become so heated by the processes of fermentation and permeated by the resultant gases that fly-breeding is restricted to the outermost layer of an inch or so. The heaps should be formed into a compact, almost rectilineal shape, and carefully smoothed on the sides and top by blows with the back of a shovel. The use of a borax spray composed of 1 lb. of borax in 6 gallons of water will satisfactorily deal with the insects breeding in the outer layer. As excess borax in the soil is injurious to plant growth, it has been recommended that not more than three gallons of this spray should be applied to 10 cubic feet of infected manure, and not more than 15 tons of borax-treated manure per acre be distributed in the soil.

For mounted army forces and farms, the method of drying manure may be useful. The process simply consists of spreading the manure in a thin uniform layer so that it dries quickly in the sun, thus rendering it unsuitable to the fly for oviposition. An area of flat hard ground should be selected and a rotation of freshly-placed manure, dry manure, and bare ground could be kept up in order to deal with fresh accumulations. The drying manure should be raked over. When dried the manure could be stored safely for agricultural purposes. It will be understood, however, that manure dried in this manner would have a diminished fertilising value, and it would be useful mainly because of the humus it would provide.

In city areas, the control of the house fly generally depends on the care taken in garbage disposal, and garbage should accordingly be placed in a fly-proof garbage tin. Regulations regarding the building and care of household conveniences are in force, and each householder should see that so far as he is concerned, the regulations are strictly obeyed.

DESTRUCTION OF THE ADULTS

The adult flies that gain access to a building may be dealt with in a variety of ways, as for example swatting, the use of sticky fly-papers, fly sprays, and trapping.

There are several brands of fly sprays on the market, and these generally consist of definite contact insecticides, which kill either on actually wetting the insect or as partial fumigants as a result of the fumes that are liberated when the fluid is sprayed in a fine mist.

A home-made spray may be somewhat inexpensively prepared by stable owners and farmers. The recipe is as follows: ½ lb. of pyrethrum is stirred into 1 gallon of kerosene and the mixture is agitated at intervals for two hours. Settling is then allowed to take place and the resultant clear amber-coloured fluid is later decanted or syphoned off. This spray fluid, if prepared with water-white kerosene, may be safely sprayed in furnished rooms. Householders, however, will usually find it more convenient to purchase one of the ready-prepared sprays.

It is advisable to sweep up and burn the flies that fall as a result of spraying, as a number of them may merely be stupefied and, if left, may later recover.

Traps of a multiplicity of designs have been used for house fly control, the most commonly known type being the glass bottle trap with the entrance in the bottom and with an internal trough. The trough holds a fluid which serves both to lure the flies into the trap and also to drown them. Various fluids may be used for baiting this style of trap, including milk and stale beer.

Trapping should, however, be a somewhat needless procedure, or at least it is a method to be adopted only as a last resort. If flies are sufficiently numerous in a building to warrant the use of traps, then all efforts should be directed to the elimination of the source of the flies and, if necessary, to the adequate screening of the building.

THE NUTRITION OF INDIAN CATTLE*

ANIMAL nutrition as a subject of research in the laboratory has received considerable attention in other countries for some time past, but the results which have been obtained have not been adequately discussed in relation to the conditions pertaining to cattle in India. This is no doubt due to the fact that we have not yet gathered sufficient knowledge about the dietary requirements of Indian cattle for various purposes, nor do we know much about the nutritional condition of our cattle in relation to their resistance to disease. The information which has been obtained so far is mostly contained in technical publications and as such is not readily available or intelligible to the ordinary farmer. For this reason it is thought desirable to present in a general way some of the known facts concerning the rôle of nutrition in relation to various cattle problems. In this article, which is the first one of a series, we shall deal with some of the nutritional factors which affect breeding operations.

The important cattle requirements in India are the heavy milking type and animals for draught purposes, and animal breeding for these dual requirements has received considerable attention. The production of beef cattle which is of great importance in Western countries, is not of so much importance in India owing to the religious beliefs and practices prevalent, but a great demand exists for better class hides and for bones and bone meal as fertilizers. Cattle manure is also an extremely valuable fertilizer, but unfortunately the dung is used more as a fuel than as a manure. According to an interesting report issued by Colonel A. Olver and Mr. M. Vaidyanathan of the Imperial Council of Agricultural Research, it is estimated that the total cash value of animal products in India amounts to about 2,000 crores of rupees and is appreciably higher than the cash value of the crops. The importance of the study of cattle-breeding from various standpoints is thus obvious.

It is now generally realised by nutritional workers that diet has a great effect on the condition of animals, and though in certain respects genetical considerations of breed, etc., prevail most, the nature of the diet may act as the limiting factor in the performance of these animals. Thus it is known that to keep up the efficiency of a draught animal or of the performance of a milch cow it is necessary to provide each with the type of ration best suited to its particular need. This has been the general experience of a large number of workers though we lack accurate knowledge about the dietary needs of a working bullock. It is also known that a good breed will deteriorate if kept for a long time on a defective ration, and it is probable that the observed degeneration of most of the indigenous cows in India is to a large extent dependent on the undernutrition and malnutrition suffered by them. The quality of the milk produced is also directly related to the quality of the ration supplied and the position of this problem may be briefly summed up as follows :

By K. C. Sen, D.Sc., Biochemist, Imperial Institute of Veterinary Research, Muktesar, in "Agriculture and Live-Stock in India."—Vol. III Part VI. November, 1933.

Since milk is a secretion designed primarily to keep the calves in vigour and make their normal growth possible during the early stages of life, it must contain all the substances essential for animal growth. Also, these important constituents of milk must come ultimately from the food supplied, as it is known that the mammalian body does not synthesize many of the things which are of most importance for animal growth. This means that in order to keep up the high dietetic value of milk, a proper and sufficient amount of nutrition must be supplied to the dam. A large amount of work has been done to show that if an animal is kept indoors, or stall-fed, usually on artificial foods of restricted nature, the milk may be lacking or be highly deficient in these important physiologically active substances and this will act very unfavourably on the condition of the calves. Also, the ration is likely to be deficient in proteins and minerals which means that the animal herself is going down in health and that, since minerals are important and essential constituents of milk, their deficiency may be a limiting factor in the milk production. This is one of the reasons why in many heavy milkers there is a sudden diminution of milk yield after a preliminary period of high milk production, and the stunted growth of farm animals in many parts of India is also probably connected with the same factors.

It will be interesting at this point to give an illustration of what can be done to improve the performance of dairy cattle by judicious feeding.

One of our dairy cows, Tili, IV, No. 113, bred at Muktesar is a half-bred, Holstein-Sindhi, born on 14th January, 1925. In her first lactation she gave 2,496 lb. of milk in the first 300 days and in her second lactation 2,438 lb. only. The ration consisted of the usual concentrates and grass or hay and grazing was allowed. This milk yield was considered to be low, and it was decided to give 4 oz. of bone flour per day from the dry period after the second lactation. At the same time some of the fields where these cows are grazed were well manured. In the third lactation the milk yield for the corresponding period was 4,064 lb., *i.e.*, an increase of about 1,600 lb. The feeding of bone flour was continued throughout the third lactation period and the subsequent dry period and improved grazing was also provided. In her fourth lactation, she has already given 10,000 lb. of milk in 293 days, the average butter fat being 3·5 per cent., and the maximum daily yield of milk being 44 lb. We consider that this remarkable increase in milk production is to a large extent due to better dieting of the animal.

Milk supply is, however, only one of the various questions with which a farmer has to deal in his breeding operations. Obviously in this connection, he will endeavour to keep his animals free from infectious disease and keep up the fertility to the maximum. Thus he would expect a high birth rate in his herd, and the calves should be normal and healthy ones. Occasionally, however, he finds that some of his animals have aborted or that the calves are very weak and may either die or have to be destroyed soon after birth. The question of contagious bovine abortion is an important one when dealing with problems of cattle-breeding, but as yet it has not come under the domain of nutritional disorders and has to be left out of the present discussions. But it is known to many laboratory

workers that we have often to deal with cases of abortion which are non-specific in origin. It has been known for some time past that malnutrition, especially deficiency of lime or phosphorus or both in the ration, may lead to either sterility or abortion in the female. Sometimes there may not be any abortion, but the calf is weak and may not survive long. Thus it was demonstrated about twenty years ago by some American workers that a lime-deficient diet produced abortion in cows or lead to the birth of weak calves. A deficiency of lime is very common amongst stall-fed animals because though they get a large amount of concentrates supplying a sufficient amount of protein and a comparatively large amount of phosphorus, there are no good sources of lime in the ration unless a large amount of rich pasture, such as lucerne or clover, or a good type of hay or silage is also added. Lime deficiency therefore usually occurs where no grazing can be obtained and better types of fodder are not available. One of the commonest symptoms of this lime deficiency in animals is their attempt to eat earth and mud in their pens, and it ought to be realised that all young animals have a great craving for minerals owing to their high requirement for bone construction.

Another important mineral which effects the fertility of domestic animals is phosphorus. It has been found that natural pasture in many parts of the world is highly deficient in this mineral, and as such many indigenous cattle develop a condition known as aphosphorosis due to lack of this mineral in their food. The animals become emaciated, get a depraved appetite such as chewing of bones, carcases or refuse matters, are prone to infectious diseases and become partially or completely sterile. The addition of a phosphorous-rich substance in the diet, such as bone meal (which incidentally, contains a large amount of lime as well) improves their condition. A good deal of work has been carried out in America and in South Africa, and it has been found that phosphorus starvation in cattle leads to diminished fertility and diminished milk yield. Thus in one experiment it was found that the addition of bone meal to the ration raised the milk yield by 40 per cent. and increased the average number of calves born in a herd by 30 per cent. It is thus apparent that sterility can be produced by a phosphorus-deficient diet and this fact is of great importance in India because, it is known, the natural pastures in this country are highly deficient in phosphorus. In the case of well managed dairies this deficiency may not immediately lead to any untoward symptoms owing to their supplying a large amount of concentrates, but the importance of this deficiency may be easily perceived in the case of less well managed herds in the villages. Thus it is common knowledge that in many parts of the country, the cattle are emaciated, mortality is high and sterility is common. It is, of course, not possible to say how much of these defects are due to gross undernutrition and how much to malnutrition. Obviously, however, the intelligent farmer has to see that his animals are not kept on mineral deficient diets, because apart from the question of fertility, other disorders might be encountered which are directly or indirectly due to faulty rationing. Fortunately milk fever, which is a common cause of trouble in Western countries, rarely occurs in India, but anæmia, goitre, rickets, osteoporosis, unthriftiness and staring coat, emaciation and loss of condition, pica, etc., are all known to occur due to faulty mineral metabolism and in all these cases one has immediately to rectify the errors of dieting. Attempts have also been made to correlate the greater prevalence of tuberculosis and Johne's disease in heavy milking cows with a lime deficiency in the ration.

There are some other minerals which seem also to have an effect in breeding operations. Thus it is believed that an excess of fluorine in the diet may cause sterility. This, of course, may occur in practice only in fluorine-rich areas, especially where flour-spar deposits occur. This substance is found in India in certain parts of the Central Provinces (Raipur District) and in some places in the Punjab and Madras Presidency. Another important mineral is iodine. It has been found that in iodine-deficient areas, endemic goitre tends to occur and breeding difficulties in domestic animals are experienced. In stall-fed animals also, there may be a relative deficiency of iodine in the food which adversely effects reproduction.

We have discussed the rôle of some minerals in relation to fertility. Some other factors, also of nutritional origin, may now be briefly mentioned. Attempts have been made to correlate vitamin deficiency with sterility. It is known now that the absence of vitamin E, present in many vegetables, notably lettuce, and in cereal embryos, specially wheat, and of vitamin A, present in cod liver oil, in milk and other substances, causes degeneration of the germinal epithelium and hence sterility. Vitamins B and D have also been studied in this connection, but no definite conclusions have been reached. It is realised, however, that many of the positive results obtained in this connection may not be true under field conditions. There is, however, a possibility that, under an intensive system of dairying with stall-fed animals, specially where green pasture is not available, there may be a deficiency of vitamins A and D, which will induce degeneration of the epithelial tissue on the one hand, and a metabolic derangement of lime and phosphorus on the other hand. These conditions may lead, in actual practice, to certain breeding difficulties, such as birth of blind calves or weaklings which are a source of constant trouble in some well-established dairy farms in North and North-Western India. A striking case of this nature is a calf which was born blind, the dam being a heavy milker. In addition to blindness, there was a teratomatous growth on the eye balls, and the nose bone was twisted. In other cases, twisted neck or other bony deformities occur with blindness, and the trouble seems to be very common in Sind and Baluchistan. Apart from these deficiencies, a hypo—or hyper-function of some of the endocrine organs, such as the thyroid and pituitary, may cause sterility, but these deranged endocrine functions are likely to be correlated with unbalanced rations supplied to the animals. These points as well as others related to some contagious diseases have been reviewed in a recent publication of the Imperial Bureau of Animal Nutrition which has been reprinted in the June, 1933 issue of the Indian Journal of Veterinary Science and Animal Husbandry, and may be read with profit.

In concluding this article, mention may be made of some attempts to improve the quality of the cattle in this country and some interesting observations that have been recorded. The most systematic and successful attempt to improve the cattle of a province has been made in the Punjab and there we are now in possession of three good breeds, viz.: Hariana as a dual function animal, Sahiwal as a milking breed and Dhanni as a draught animal. A very curious fact is that most of the good animals in India come from the tracts where rainfall is low and water is scarcely available. With the increase in the irrigated areas and consequent increase of crop production, grazing areas are getting fewer and animals coming

from irrigated tracts are much inferior in condition so far as their performance is concerned, and, moreover, these animals are more susceptible to parasitic infections and disease in general. This observation is of the highest importance to agriculturists and animal-husbandmen alike, and attempts should be made to find out if this difference in disease susceptibility and in performance is due to climatic considerations, to nutritional differences or to any other causes. The Punjab experiments, however, have shown how much it is possible to improve the local breeds by selective breeding and judicious feeding, and experiments made in Pusa support the idea that good animals can be raised from almost any breed of animal available in India provided the degeneration has not proceeded too far.

Improvement in cattle breeding operations in this country therefore involves a number of considerations, such as better control of disease, provision of good pedigree bulls and castration of scrub animals, provision of more grazing by opening up suitable forest areas, conserving the excess pasture and fodder by ensilage, drying, etc., so as to be able to provide a suitable diet throughout the year. It will be obvious that in many of these considerations a knowledge of the nutritional requirements of his animals will be of great asset to the farmer, and many of the difficulties experienced by him, *e.g.*, irregular breeding and questions connected with fertility in the herd, as well as many of the disorders of nutritional origin, may be overcome if attention is paid to proper dieting. As an industrial proposition, since cattle are of value both while living as well as when dead, it is essential that the cattle breeding question should be approached from the broadest standpoint and attempts to get the utmost return out of the animals while living, and also the best value for their hides, horns and bones when dead. It is not always realised after an animal is dead, that its hide, bones and horns are products of the nutritional and metabolic adjustments which took place throughout the years while the animal was living, and that their value will depend to a certain extent on these factors. It is likely also that the susceptibility of cattle to some parasitic infections, which diminish the value of their hides so enormously, may be modified to some extent by dietary modifications, but nothing definite on this subject can be stated at present. Considerable research will be necessary before we can correlate nutritional deficiencies with susceptibility of the animal body to the various types of parasitic infections and disease in general, but the tendencies in modern nutritional works indicate that a close relationship exists between the dietary supply to and the disease-resistance mechanism of the animal body.

CITRUS FRUIT GROWING IN RHODESIA*

Introduction.—Five years ago an article bearing the above title appeared in this journal, but in bulletin form it has for some time been out of print. Since that date a considerable amount of experimental and investigational work has been conducted throughout the citrus-growing countries of the world, and as a direct result we are now more conversant with the requirements of citrus trees than we were then.

The time, therefore, seems appropriate for writing up this subject again, and in doing so it is proposed to deal with all the important phases of the industry to enable the beginner to establish and maintain his small or large planting in the best possible manner.

Rhodesia has vast tracts of country suitable for the growing of citrus fruits, and the writer has been agreeably surprised at the excellent results obtained under a very wide range of soil and climate conditions. Citrus fruit trees have been successfully established in Rhodesia at elevations up to 6,000 feet, and the soil chosen vary from light sands to heavy loams, and the advice here tendered is based upon personal observation within the Colony, supported and enhanced by successful practice in citriculture in other parts of the world.

There are ups and downs in all branches of farming, particularly when seasons and markets are unfavourable, but the average net profits derived from well tended citrus groves are usually sufficient to warrant the undertaking.

If a sound agricultural venture is contemplated it is advisable to adopt a system of mixed farming in preference to depending entirely on one branch of agriculture, and as there is an ever-increasing consumption of citrus fruits brought about by extensive advertising and propaganda work, the citrus industry should commend itself to those wishing to augment their income.

Climate.—Southern Rhodesia, with a few exceptions, possesses a desirable climate for the successful growing of most citrus fruits. There are, however, three factors that require careful consideration, namely:

Winds.

Temperatures.

Rains.

Wind.—There is little if any necessity to consider the wind factor during the greater portion of the year, as this Colony is singularly free from injurious wind storms during the months of November to July. In the remaining months of August to October the wind is fairly strong and consistent, and if adequate provision is not made to exclude these dry winds from citrus groves there is every reason to assume that the setting

* By G. W. Marshall, Horticulturist. Extracted from *The Rhodesia Agricultural Journal*, Vol. XXXI, No. 1. January, 1934.

of the fruit that takes place at this season of the year will be adversely affected. What actually occurs in an unprotected citrus grove during this dry and windy period may be summarised briefly as follows:

When citrus trees are in active growth during dry and windy weather the transpiration of moisture (through the plant's breathing pores) exceeds the absorption of soil moisture by the tree's root system, and when this occurs an excessive wilting of the young growth and newly set fruit will be the result. This wilting becomes more pronounced as the summer temperature increases, and must be prevented, otherwise a heavy drop of immature fruit will be the result, due to the re-absorption of a portion of the moisture content from the fruit by the foliage.

In a citrus grove well protected by wind-breaks the transpiration of moisture is considerably reduced during dry and windy weather, and the evaporation of soil moisture is also restricted, thereby enabling the tree to function in a normal manner. If our atmospheric moisture were high at this season of the year the winds would not produce this excessive wilting and good crops of fruit could be expected even in unprotected groves. The humidity of the atmosphere along the eastern border is relatively high when compared with the rest of Rhodesia, and the further west we proceed from this area the greater becomes the necessity of providing suitable shelter for the groves.

Temperatures.—In the tropics this factor is generally of minor importance. Owing to our altitude, we experience a temperate to sub-tropical climate in most districts of the Colony, and these areas are ideal climatically for the production of citrus fruits on account chiefly of the absence of extremes in temperatures. In a few areas located at the lower elevations sun-scald is at times somewhat troublesome. This may be overcome to a marked degree by choosing a site for the citrus grove with a southern or eastern aspect, or when tall-growing trees are established on the western side of the grove.

Low temperatures must be considered occasionally, and citrus trees should not be planted at the highest elevations where severe frosts occur, nor along water courses or low-lying ground where the temperature may fall below 30°F. Many citrus varieties differ in their degree of resistance to low temperatures, and it would not be wise to establish some of them where the minimum temperatures fall below that stated. At or above this temperature there is little or no fear of injury occurring to the trees or fruit. It is undoubtedly an advantage to have slight frosts during the winter months. Low temperatures improve the colour of ripening fruit and retard the ravages of many insect pests, besides improving the physical condition of many soils.

Rainfall.—Rhodesia enjoys a summer rainfall ranging from an annual average of about 10 inches along the south-eastern border, 20 to 25 inches through the Midlands and western territory, 30 to 35 inches or more over the higher elevations of the north-eastern areas, and occasionally 100 inches or more along some of the mountainous regions of the eastern border.

Owing to the greater portion of the precipitation occurring during the comparatively short season (November-March) it is unwise to establish citrus groves where irrigation is not possible.

Citrus growing countries experiencing a summer rainfall have many advantages over countries with a winter precipitation, the chief being the absence generally of any need to irrigate during the period of most active tree growth and fruit development. Further, a greater variety of suitable cover crops may be grown during the summer months, and the fruit also is harvested and marketed in the dry season and thus has better carrying and keeping qualities than fruit harvested during damp or wet weather.

Selection of the Site.—The most important factors to be considered when selecting a site for the establishment of a citrus grove are suitability in respect of:

(*a*) Aspect.

(*b*) Soil.

(*c*) Irrigation possibilities.

(*d*) Shelter.

(*e*) Transportation of fruit.

If one or more of these factors are disregarded when selecting the site, poor and unprofitable crops of fruit may be the result.

Aspect.—The best site to select for the citrus grove is one with a gentle southern or eastern slope. Northern and western aspects are often undesirable.

The slope of the site should not be excessive if soil erosion is to be avoided during heavy rain storms or irrigation. The best slope for planting citrus trees will vary with the nature of the soil, but it should never, if possible, exceed one in a hundred.

Situation of site.—If severe frosts or hail storms have been experienced in the vicinity of the site favoured, careful enquiries should be made, and if there is any likelihood of severe damage occurring from these causes the locality should be avoided. Fortunately the greater portion of Southern Rhodesia suffers little from either of these troubles, and they seldom need to be considered.

The soil must be suitable for citrus trees and must be capable of being irrigated, preferably by gravitation. The site must also naturally be sheltered from winds or be capable of being sheltered artificially. Where possible it should be located near a good road or railway line.

Soils.—Citrus fruit trees are grown on a variety of soils throughout Southern Rhodesia, ranging from light sands to heavy loams. The yields, quality and keeping properties of the fruits produced on such a range of soils vary considerably, and if payable crops of high quality and good keeping properties are to be successfully produced, great care must be exercised in selecting the soil. Heavy soils are undesirable; they are difficult to work and the quality of the fruit they produce is often poor. The trees are also more susceptible to root diseases, particularly during wet seasons, when this class of soil is likely to become water-logged, though good quality fruit may be produced in such soils during dry seasons. The disadvantages of the heavy soils outweigh the few advantages they may

possess, and they should be avoided if lighter soils are available. The best soil for the profitable production of citrus fruit is a light or medium sandy loam with good depth and drainage. Citrus trees will not tolerate wet and cold sub-soils.

Suitable soils as described above will furnish the trees with a large root-feeding area. The trees are capable of growing to a large size, living to a great age and producing large crops of good marketable fruit.

On shallow soils with impervious clay sub-soils or over-lying solid rock, young trees may thrive and flourish for a few years, but when the tap roots encounter the objectionable sub-soil the trees will rapidly decline or die and prove a great disappointment to the owner.

If sandy loams are unavailable in any given locality it would then become necessary to select a medium loam which may be either grey, chocolate or red in colour. Heavier soils than these recommended should be avoided if best quality fruit is desired.

A simple classification of Southern Rhodesian soils suited for citrus culture is:

(1) Alluvial sandstone formations.

(2) Medium texture granitic deposits.

(3) Contact soils of a sandy nature.

(4) Medium loams.

The minimum depth of a good citrus soil must not be less than four feet, and it should be well drained naturally.

The root system of a citrus tree differs from that of many other trees, in that it develops both tap and lateral roots strongly. The tap root is well defined and strikes downward into the soil, whereas the lateral roots develop horizontally and they are frequently to be found within a few inches of the surface of the ground. These roots are often referred to as the drinking or feeding roots of the tree.

Early South African planters realised that their seedling orange trees would often only thrive up to a certain stage and then rapidly decline or die. Upon investigation it was usually discovered that the tap roots of the dead or unthrifty trees has encountered objectionable sub-soils. To overcome this trouble many of the subsequently planted trees were set in groves over a large flat stone, the idea being to deflect the tap roots and produce a secondary system of lateral roots. The object in view was defeated owing to the tap roots again striking downward immediately they came to the edge of the flat stones. This method of planting is still practised by a few of the older South African farmers.

During Dr. H. J. Webber's citrus survey of South Africa in 1925 he was particularly impressed with the layered citrus trees he had in the Cape and Transvaal Provinces of the Union of South Africa. Many of these trees were of great age and in most instances had out-lived the seedling trees planted at the same time. As the layered citrus trees are devoid of tap roots this would possibly account for their longevity. Layered trees are more suited to the shallower soils, on which they are likely to prove a greater commercial success than seedling or grafted trees.

Shelter.—Many old and unpruned citrus groves are to be found at the present time in South Africa. If the owners of these groves were to realise what their annual crop losses were on account of lack of shelter they would be astounded. While dealing with this subject it may be well to refer to what actually occurred on a Western Transvaal estate. Nearly 20 years ago an unpruned and grossly neglected citrus grove was acquired by its present owner, who immediately established shelter belts of rapid-growing trees round the grove, at the same time adopted modern manurial and cultural methods, with the result that the annual crops of fruit increased in seven years from 400 cases to 25,000 cases. This increase in crop production was most pronounced where the citrus trees derived benefit from the rapidly growing shelter belts. The crops harvested were 10,000 cases in 1923, 17,000 in 1924 and 25,000 in 1925. The shelter belts protecting these groves were from 15 to 20 feet in height in 1923, and at the end of 1925 the same trees had attained a height of from 30 to 40 feet.

This instance of the increased crops of fruit harvested from the sheltered groves is an outstanding example of what may be done in the way of sheltering even old trees. These shelter belts were undoubtedly largely responsible for the greater portion of the increase in crop production, save on the few small sections where the citrus trees received inadequate shelter the crops were generally very poor, although all of the trees had received the same manurial and cultural treatment. One of the additional benefits derived from these shelter belts was the marked improvement in the outward appearance of the fruit, there being little or no mechanical injury throughout the adequately protected sections. Of all the fruit harvested, there was slightly under 3 per cent. of "culls"; most of this injury could be attributed to other causes than wind, the chief being bud-worms and malformed fruits.

The citrus groves just referred to were inspected by Dr. W. J. Webber during his tour of investigation of the South African citrus industry. He was particularly well impressed with what he saw, and at the time stated that the trees were the best conditioned that he had so far seen in South Africa.

Reference has been made to the importance of providing suitable shelter for the groves where no natural protection is to be found. The following remarks will be confined to when, how and what to plant.

Having selected a suitable site for the grove, shelter belts, where already existing naturally, should be established without delay. It is to the advantage of the citrus trees if shelter belts which are required to be established be planted a few years in advance of the grove they are to protect, as young citrus trees require protection from the time of first planting out if the best results are to be assured. This is not always feasible, however, particularly with new arrivals to the country who desire to establish groves without unnecessary delay. In instances such as this the shelter trees should not be planted later than the fruit trees they are to protect, and meanwhile rows of some of the more quick-growing temporary shelter plants such as dhal may be planted at close intervals around and through the grove to afford protection until the permanent shelter trees become effective.

The best time of year to plant all shelter trees is during the months of December and January. By planting at this season, when rains are usually frequent, it should be possible to establish the trees well before the dry season commences.

The preparation of the land for the grove and shelter belts should be effected at the same time. Both the fruit and shelter trees are to be planted at the same season. The soil should be deeply ploughed and brought to as fine a state of tilth as is possible. The preparation of the land is by far the most important factor in the successful establishment of a shelter belt. Many disastrous failures in the establishment of shelter or other trees are often recorded, and upon investigation it is usually found that little attention had been devoted to preparation of the soil, very small holes perhaps having been dug or the trees planted in a careless manner. The few trees that survive such treatment are generally stunted or weakened to such an extent that they fall early victims to the ravages of white ants or some other pest.

When the soil has been brought into the best possible condition the shelter belt rows should be pegged with the inner row parallel with that of the intended first row of citrus trees, but 70 feet distant. This row should be pegged according to the distance apart it is intended to space the shelter trees, this being usually 8 feet. Each subsequent row should then be pegged in such a manner as to have the trees alternating or three trees forming equilateral triangles. Each side of the grove to be protected should be pegged in the same manner, and the process will be the same if it be two or more rows of shelter trees.

After the pegging process is completed the tree holes should be dug the same size and in the same manner as described under planting of the citrus trees.

All young saplings trees should be carefully lifted with a good ball of earth attached to the root system. If any bent or damaged root is visible it should be straightened out and pruned slightly. The shelter trees may then be set into their permanent positions at the same depth as they were previously in the pots or nursery beds. After filling in the necessary soil the trees should be well firmed and watered if weather conditions render it advisable.

Cultivation should be given to the soil round each tree after each watering or during the spells between the rains. This is extremely important, as it keeps down weed growth, conserves soil moisture and allows the trees to grow unhindered. If the necessary care and attention are paid to the young newly-planted tree it should be possible to secure an even stand of uniformly well-grown trees to furnish the required shelter.

Preparation of Land.—The ground should be deeply ploughed and brought into good tilth as soon as possible after the end of the rainy season—about March. When the ground is prepared at this season most of the soil moisture will be conserved and the latter operation of digging the tree holes will be made easier.

It is also necessary to give the most careful attention to the problem of how to irrigate the proposed site of the grove. The advisability of grading the land before the trees are planted cannot be too strongly

emphasised, as the efficiency of the irrigation scheme so much depends upon the proper grading of the situation. After grading, the whole area should be reploughed, cultivated and brought into the best possible condition, and if it can be arranged a trial irrigation should be given to ascertain which fall will be most suitable for planting the rows. The rows should preferably be short, with not more than 15 trees to each row. Such rows would be 120 yards in length and the fall should be about 6 inches per 100 feet, according to the nature of the soil, sandy soils requiring a greater fall than those of a medium or heavy character.

When trees are planted on an ungraded soil continuous trouble will confront the grower, and as it is neither easy nor economical to grade the slopes of an established grove, this work should be done prior to the planting. The additional cost of a properly graded site is more than justified on account of the ease with which all of the cultural and irrigation operations may be performed. On ungraded slopes the trees will receive irregular supplies of water, and this in turn will necessitate more frequent irrigation, while additional labour will be necessary to control the irrigation water. Depth of ploughing will also be uneven; silting will occur in the depressions, thereby endangering the health of many of the trees, and the texture or quality of the fruit may be adversely affected.

Laying out the Grove.—After preparing the chosen site in a thorough manner it should be carefully laid out with the rows of trees planted along the contours, allowance being made to permit of the irrigation water flowing evenly without displacement of the soil. The necessary appliances for the pegging out of the site are:

Planting wire to set nine tree pegs at a time (68 yards). For this purpose No. 16 galvanised plain wire could be used, and lumps of solder or rings of wire should be connected at the distances apart it is intended to space the trees. A 3-in. ring must be attached to each end of the wire 6 ft. from the end solder mark. This facilitates the adjusting of the wire to its exact position when the pegging operation is proceeding. Two ½-in. iron pins 24 ins. in length will be suitable to hold the wire in position while the marker pegs are being set. Sufficient white wooden pegs or Spanish reeds 12 ins. to 18 ins. in length and about 1 in. in diameter should be available to allow of using three pegs for each tree to be planted. A few 3-ft. pegs are also necessary for setting the corner and wire length main pegs.

The systems for the laying out of groves and orchards are:

(1) The square or rectangular.

(2) The hexagonal or equilateral triangle.

(3) The quincunx.

Of these, the square or rectangular method is recommended for adoption in Rhodesia where land is inexpensive. This square system facilitates all cultural operations, chiefly on account of the wider middles (space between the rows of trees). It permits of ploughing and cultivation being carried out in four directions, and each tree has a greater root-finding area than that obtained in other systems of planting.

The hexagonal or equilateral system of laying out a grove will allow of more trees being planted to the acre, 86 trees being necessary for the hexagonal as against 76 trees for the square system. The hexagonal system of planting has one great disadvantage as compared with the square system, in that ploughing and cultivation can only be done in three directions.

The quincunx system is only of use where temporary trees are to be planted among permanent ones. The lay-out of this system is the same as that of the square system, but with a fifth tree in the centre of each four permanent trees.

If a mixture of citrus and paw-paw trees is desired this system will be found ideal. Paw-paw trees being short-lived, they may be used as the temporary fifth tree and then rooted out when the citrus trees require additional space. The square system of planting being considered to be the most suitable for Rhodesian conditions, there is no necessity to deal further with the other systems referred to.

Distance Apart to Plant Citrus Trees.—Citrus trees should never be planted nearer than 24 ft. apart each way, and this distance applies to all varieties of citrus. If seedling orange trees are to be planted it would be advisable to space them 30 ft. apart owing to the large size to which they will grow. The spacing recommended will provide each tree with sufficient room to grow unhindered, and each tree will have a large root-feeding area. Green crops also will receive more sunlight, and ploughing, cultivation, spraying or fumigation will be made easier.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 28 FEBRUARY, 1934

Province, &c.	Disease	No. of Cases up to Date since Jan. 1st 1933	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	23	8	23	...	...	...
	Anthrax	...	...	...	...	..	...
	Rabies (Dogs)	4	...	...	...	...	4
	Piroplasmosis	...	...		...	...	...
Colombo Municipality	Rinderpest	..	...	...	...	...	...
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	.	...
	Rabies (Dogs)	2	1	...	...	...	2
	Haemorrhagic Septicaemia	...	...	...	..	...	...
	Black Quarter	...	...	...	...	...	...
	Bovine Tuberculosis	...	...	...	...	...	
Cattle Quarantine Station	Rinderpest	..	...	...	...	..	..
	Foot-and-mouth disease (Sheep & Goats)	...	...	...	...	...	...
	Anthrax	16	15	...	16	...	...
Central	Rinderpest Foot-and-mouth disease Anthrax Bovine Tuberculosis Rabies (Dogs)	FREE					
Southern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	106	41	106	...	...	...
	Anthrax	...	...	..	...	...	...
	Rabies (Dogs)	...	...	.	...	...	...
Northern	Rinderpest	80	53	11	61	...	8
	Foot-and-mouth disease	...	..	...	...	...	...
	Anthrax	...	...	...	...	...	..
	Black Quarter	..	...	...	...	...	...
	Rabies (Dogs)	...	...	...	...	...	...
Eastern	Rinderpest	...	...	...	...	...	..
	Foot-and-mouth disease	22	...	22	...	...	...
	Anthrax	...	...	...	...	..	...
North-Western	Rinderpest Foot-and-mouth disease Anthrax Pleuro-Pneumonia (Goats) Rabies (Dogs)	FREE					
North-Central	Rinderpest Foot-and-mouth disease Anthrax	FREE					
Uva	Rinderpest Foot-and-mouth disease Anthrax Bovine Tuberculosis	FREE					
Sabaragamuwa	Rinderpest	..	..	...	...	..	...
	Foot-and-mouth disease	92	92	..	...	92	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	...	...	...	...	...	...
	Haemorrhagic Septicaemia	..	...	...	...	...	...
	Rabies (Dogs)	3	1	...	...	...	3

G. V. S. Office.
Colombo, 8th March, 1934.

M. CRAWFORD,
Government Veterinary Surgeon.

METEOROLOGICAL REPORT

FEBRUARY, 1934

Station	Temperature				Humidity		Amount of Cloud	Rainfall		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Inches		Inches
Colombo -	85·9	− 0·9	71·0	− 0·7	70	90	4·4	2·81	10	+ 0·62
Puttalam -	85·5	− 2·8	68·7	− 1·1	70	90	3·9	3·70	5	+ 2·41
Mannar -	84·8	− 2·2	73·8	+ 0·4	72	86	3·6	0·21	1	− 1·08
Jaffna -	84·7	− 0·9	71·3	− 0·1	68	88	3·2	0·48	4	− 0·77
Trincomalee -	81·5	− 1·4	74·1	− 1·8	75	86	5·0	2·05	9	− 0·11
Batticaloa -	81·6	− 1·4	72·7	− 0·8	79	93	5·8	10·94	11	+ 7·41
Hambantota -	84·9	− 1·3	71·6	− 1·1	74	88	3·5	3·66	8	+ 2·25
Galle -	83·8	− 2·0	72·9	− 0·4	78	90	4·6	2·10	7	− 0·81
Ratnapura -	90·9	− 1·0	70·3	− 0·9	70	97	5·0	10·50	13	+ 5·89
A'pura -	84·7	− 2·1	69·0	− 0·6	68	95	5·4	4·05	5	+ 2·47
Kurunegala -	87·7	− 2·1	68·7	− 0·9	65	95	5·8	2·00	7	+ 0·19
Kandy -	84·1	− 2·0	66·4	− 0·5	61	87	4·6	4·75	9	+ 2·45
Badulla -	77·5	− 1·5	62·9	+ 0·3	77	94	4·8	6·06	13	+ 3·10
Diyatalawa -	73·0	− 2·2	57·1	+ 1·5	74	91	6·1	4·47	10	+ 2·14
Hakgala -	68·2	− 1·5	49·6	− 0·4	73	84	6·1	8·03	15	+ 4·63
N'Eliya -	67·8	− 2·3	44·5	+ 1·1	70	89	5·7	3·78	10	+ 1·74

February rainfall was, on the whole, above normal. All stations in the Northern Province, and a few near it, reported deficit, while in the low-country to the west of the hills, excess and deficit approximately balanced. Excess was greatest on the northern, eastern, and southern slopes of the hills, and in the low-country to the east and north-east of them.

There were 10 falls of 5 inches or over reported during the month, most of them on the rainfall day 6th-7th. The highest was 6·95 inches, at Wellawe, on the 22nd-23rd.

During the first few days of the month, there was very little rain. Precipitation increased on the 5th, and there was widespread rain, heavy at many places, between the 6th and 7th. The rainfall fell off again on the 8th. and the weather continued dry till the 15th, with low night temperatures, particularly up-country, the temperature at Nuwara Eliya on the 15th falling to 29·7°F. The weather then changed, night temperatures increased, and more rain fell, while thunder was frequently reported. This rain at first was fairly widespread, but during the last few days of the month was mainly concentrated in the south-west of the Island.

Mean temperatures during the month were below normal, particularly by day. Humidity and cloud were generally above normal. Barometric pressure was below normal, and wind strength, on the whole, above the average. Wind directions were generally north-easterly.

Hail was reported from Holmwood Estate on the 17th.

H. JAMESON,
Supdt., Observatory.